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Kinesiology: From Aristotle to the Twentieth Century

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FOR that which jumps performs that movement by pressing both on its own upper part and on that which is beneath its feet. . . . Hence athletes jump farther if they have the weights in their hands than if they have not, and runners run faster if they swing their arms, for in the extension of the arms there is a kind of leaning upon the hands and wrists." [1] Such was the tone of Aristotle's writing in establishing the foundations of kinesiology.

As a branch of applied science, kinesiology did not emerge until the beginning of the twentieth century. Physical educators then incorporated the work of anatomists, physiologists, and physicists, applying it to the study of movement. The word "kinesiology" is currently interpreted as a study of the mechanics of movement, an analysis of the mechanical functionings of the muscles and of the body as a whole while performing physical activities. Workers such as Steindler,[2] however, are considering more and more that knowledge of the physiological functions of the body is an integral part of kinesiology.

Physiological concepts explain why certain mechanical phenomena are advantageous. For example, the importance of postural instability in maintaining circulation against the hydrostatic effect of gravity in the vertical stance. Knowledge that stretch will improve the tension developed by a muscle gives a physiological explanation for many sport techniques. There are also in the body a wide variety of reflexes influencing the muscular tonus upon which movement is superimposed. Thus, while kinesiology borders on the field of several sciences, its greatest practical interest is in the field of physical education where the mechanical use of the body is the function to be perfected.

The body as a machine differs from any structure that might be built by an engineer. Its internal arrangement must be accepted as fixed. The insertions of muscles cannot be changed at will in order to improve their leverage. The lengths of the bones as levers cannot be altered. Thus the grace, ease, and technique with which individuals move depend greatly upon the body build. To an important degree, the machinery of the body reacts upon itself during activity, therefore modifying the development and efficiency of its action. This accounts for differences in performance as activity progresses. But no man-

[1] Aristotle, *The Progression of Animals*, translated by E. S. Forster (Harvard University Press, 1937) 489.
[2] Arthur Steindler, *Mechanics of Normal and Pathological Locomotion in Man* (C. C. Thomas, 1935).

made mechanical contrivance, however large, strong, or speedy it may be, has ever been able to walk or run, swim or dive, lift or strike as the occasion demands. Hence the human body is unique in its abilities, and it is no wonder that the study of movement has fascinated scientists since before the time of Christ.

The writings of Aristotle in ancient Greece mark the philosophical birth of kinesiology. Aristotle (384–322 B.C.), commonly considered a philosopher, was a great naturalist. No other person approached his ability as an observer of the movement of animals until the Renaissance. Being the son of a physician, Aristotle was drawn to a study of medicine and biology. He was early left an orphan. Thereafter people often considered him vain, showy in his dress, and extravagant with his father's fortune. However, he was an industrious student and an omnivorous reader, producing the most outstanding manuscripts of his time.

Aristotle was a scientist although he did no actual experiments. His numerous writings are the results of pure, logical analysis. In *De Motu Animalium* (*The Movements of Animals*) and *De Incessu Animalium* (*The Parts of Animals*) are examples of this logic showing that he was ever looking for the law behind the phenomenon.

Aristotle foresaw the existence and importance of the center of gravity when he wrote, "The reason why an animal which is to walk erect must be both a biped and also have the upper part of its body lighter and the parts situated beneath these heavier is obvious; for only if it were so constituted would it be able to carry itself easily."[3] He went on to point out that because of this fact a man's legs are stronger than his upper limbs and that children have difficulty in walking because the upper part of the body is large in proportion to the lower half. Scientists are now able to relate these findings to the gravitational moments effective at the axes of rotation of the joints of the weight-bearing limbs. Calculating the balance of equilibrating forces, muscular and gravitational, acting at each joint enables one to see the necessity for the powerful muscles of the legs.

In foreseeing the action and reaction law later described by Newton, Aristotle wrote, "Now the man who tries to push the boat while he himself is in it and leaning upon it, naturally does not move the boat, because it is essential that that against which he is leaning should remain still; but in this case that which he is trying to move and that against which he is leaning is identical. If on the other hand, he pushes or drags the boat from outside, he can move it; for the ground is no part of the boat."[4] Other evidence showing that Aristotle thought in terms of Newton's three laws of motion is easily found in *The Progression of Animals*.

One of Aristotle's most important contributions to mechanics is his

[3] Aristotle, *The Progression of Animals*, 519.
[4] Aristotle, *The Movement of Animals*, translated by E. S. Forster, 447.

law of the lever. He stated it rather diffusely. DaVinci, in the sixteenth century, developed the concept. Neither of these two men applied this law specifically to the body, but its importance is now realized since scientists have shown that all bones of the body act as levers with the muscles supplying power at their points of insertion.

While watching animals walking, jumping, or flying, Aristotle observed the bending and stretching of the limbs, and realized that locomotion could not occur were it not for the fact that the legs were jointed. Flexion he describes as a change from a line to an arc or an angle; straightening (now called extension), as a change from an angle back to a line. He analyzes further in writing, "Moreover, without flexion there could not be walking, swimming, or flying. For since limbed creatures stand and take their weight alternately on one or other of the opposite legs, if one be thrust forward, the other must of necessity be bent. For the opposite limbs are naturally of equal length and the one which is under the weight must be a kind of perpendicular at right angles to the ground. When then one leg is advanced, it becomes the hypotenuse of a right-angled triangle. Its square then is equal to the square on the other side together with the square of the base. As the legs then are equal, the one at rest must be bent either at the knee or, if there were any kneeless animals which walked, at some other articulation."[5] Lucid thinking enabled Aristotle to deduce this important phenomenon which Steindler now calls the transformation of rotatory motion (rotation of the bones about the joints), to translatory movement (motion in a straight line occasioned by the equal and opposite rotary movements occuring with flexion and extension of the limbs).

During the twenty-two centuries that have passed since Aristotle lived on this earth, many of his observations have been scientifically proved as basic facts. Some of them have been refuted; some are still being investigated; some will forever remain hypotheses. The importance of the part he played as a founder of the study of the mechanics of movement is hardly realized by many contemporary kinesiologists. No one man since his time has contributed an equal amount of knowledge to this science, although many have added smaller shares.

One of these was Archimedes, born some fifty years after the death of Aristotle and also gifted with the superior imaginative qualities and powers of logical analysis characteristic of the ancient Greeks. While most of his life was devoted to mathematical research, he became famous through a variety of ingenious mechanical inventions which were used effectively against the Romans during the siege of Syracuse. His chief contributions to mechanics, eventually to be used by kinesiologists, dealt with the principles of floating bodies now applied in the analysis and teaching of swimming. He wrote about the center of

[5] Aristotle, *The Progression of Animals*, 510.

gravity of planes and deduced the law of the lever, although his thinking was not completely accurate in this regard. Archimedes was the last of the ancient Greeks to excell in the field of mechanics before the time of Christ.

Four hundred years later, Claudius Galen appeared as the most celebrated of ancient medical writers, specializing in the field of anatomy and physiology. He was born about 130 A.D. in Pergamus, a city of Greek culture. Being attracted to science, he studied medicine. Later he became a medical attendant to gladiators and then the personal physician of Marcus Aurelius. Galen created the science of anatomy by dissecting and experimenting instead of observing and deducing as others had done. In Rome he instituted public lectures and demonstrations in anatomy and physiology and was first to describe the positions and actions of the muscles. This laid a definite foundation for the anatomical field so closely related to kinesiology. Galen retained his position of leading anatomist until the time of Leonardo daVinci.

For centuries the performance of all legal dissection was limited to studies on lower animals. The Church, strongly influencing all culture, passed laws forbidding the dissection of any human body. Hence, knowledge of the actual structure of man was extremely limited and erratic until the year 1230, when Frederick II, then King of the Holy Roman Empire, legalized the study of human anatomy. Scattered medical men took advantage of this but made no great progress until there appeared a man who became famous as an artist. This was the Florentine, Leonardo daVinci, who lived from 1452 to 1519.

Leonardo, an illegitimate child hated by his step-brothers, grew up in his father's household; and in consequence of his interest in drawing was apprenticed at the age of fourteen to the artist Andrea Verocchio. Here he developed not only artistic ability but a taste for science. He grew to think that every obstacle could be overcome by resolution. He would set a problem for himself and then go about solving it, being very solemn and meditative, since he considered that solitude alone gave time for study. For years he held no important positions since his scientific interest diverted him from the more purely money-making aspect of his art. In 1483 he was invited to the Court of Milan where he stayed till 1499 as a military engineer.

DaVinci was a prolific writer although most of his manuscripts were not published until three centuries after his death. This is explained by the fact that he wrote illegibly and with his left hand, using mirror writing, many abbreviations, and no punctuation. He may have wanted to keep his writings secret until they could be published. On the other hand, mystification of his companions was one of his pleasures. He was a practical joker and was suspected, wrongly, of mystic practices.

Like Aristotle, Leonardo foresaw many of the fundamental prin-

ciples which would be used in kinesiology. In stating, "Nothing whatever can be moved by itself, but its motion is effected through another. This other is force," [6] and "an object offers as much resistance to the air as the air does to the object," [7] daVinci was offering examples of what was later called by Newton the principle of inertia and the law of action and reaction.

Unlike Aristotle, Leonardo experimented and presented proof for many of his statements. The problem of the center of gravity interested daVinci; first, because he was an engineer and had to consider the stability of the structures and machines he devised; second, because he was an artist and was concerned with the balance of the human frame. Many of daVinci's notes on the center of weight occur incidentally to his studies on the poise of the human body. He realized that the center of gravity must stay near the center of the base of support; and in the comments in his *Treatise on Painting* he noted that when people stand on one leg, an arm or some other part of the body is extended in the opposite direction for a counter balance. He presents a concise kinesiological analysis in writing: "A sitting man cannot raise himself if that part of his body which is in front of his axis does not weigh more than that which is behind that axis without using his arms. A man who is mounting any slope finds that he must involuntarily throw more weight forward, that is, in front of the axis and not behind it. Hence a man will always involuntarily throw the greater weight toward any point whither he desires to move than in any other direction."[8]

He recognized the desirability of flexing the joints before jumping when he wrote: "Nature will of itself, and without any reasoning in the mind of a man going to jump, prompt him to raise his arms and shoulders by a sudden motion, together with a great part of his body, and to lift them up high, till the power of effort subsides. This impetuous motion is accompained by an instantaneous extension of the body which had bent itself, like a spring or a bow, along the back, the joints of the thighs, knees, and feet, and is let off obliquely, that is upwards and forwards; so that the disposition of the body tending forwards and upwards, makes it describe a great arch when it springs up, which increases the leap."[9]

In his manuscript on "The Flight of Birds" daVinci deals with problems of wind pressure and shows how a shifting of the center of gravity and center of resistance from the air would change their flight. He drew plans for many kinds of flying machines and then devised a parachute with which to escape the "doom of peril." The sketches accompanying his manuscripts are particularly illustrative.

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[6] Ivor B. Hart, *The Mechanical Investigations of Leonardo daVinci* (Chapman and Hall, Ltd., 1925) 79.

[7] *Ibid.*, 81.

[8] *Ibid.*, 102.

[9] Leonardo daVinci, *A Treatise on Painting*, translated by John F. Regaud (George Bell and Sons, 1892) 29.

As an artist daVinci was unsurpassed. His study of the body must have sprung from the wish to represent surface anatomy as perfectly as possible in his drawings. He undertook dissections not only to obtain anatomical data but also to arrive at a clear understanding of physiological processes, corroborating his investigations by experiments, proofs, and tests drawn from both physics and mathematics. His deficient nomenclature is compensated by the extraordinarily clear drawings of every part of the body. Ingenious was his device consisting of copper wires attached accurately to a skeleton at the points of origin and insertion of the muscles, thus enabling an elucidation of the changing action of these muscles as movement progressed. He emphasized, too, the important fact that the extensor muscles of a joint undergo stretching while the flexor muscles are contracting. In accomplishing these anatomical studies, Leonardo dissected some thirty human bodies as well as the carcasses of many animals.

DaVinci lived during the Renaissance, a time when many sciences which had been dormant for centuries were gradually awakening. The fact that men like daVinci, Galileo, and Newton followed closely after one another, helped bring them to life. Galileo was born some forty-five years after the death of daVinci, and Newton arrived during the year of Galileo's death.

While Galileo is best known for his astronomical discoveries, he did contribute a considerable amount of knowledge which could be applied to the study of equilibrium and movement of the body. This Florentine showed many mental aptitudes from boyhood on, his favorite pastime being the construction of toys and machines, or models of windmills, boats, and other mechanical contrivances. Galileo lived in an unsatisfactory home atmosphere. The quick-tempered members of his family were continually disputing. Money was never plentiful and, after the death of his father, Galileo was constantly in debt while trying to pay his sisters' dowries and at the same time support the many people who depended upon him. This did not interfere with the development of Galileo's mental faculties. While engaging in conversations, he would suddenly exclaim that he had discovered a new law or had solved some mathematical problem that had been puzzling him.

All of Galileo's declarations were experimentally sound. However, the world was not quite ready to accept even the scientific proof which he presented in refuting some of Aristotle's teachings. The public demonstration of the law of falling bodies from the leaning tower of Pisa is a classic. The Peripatetics, firm advocates of Aristotle, would not believe their eyes when they saw a ten-pound and a one-pound shot dropped simultaneously from the top of the tower hit the ground at the same instant. Instead, they went on teaching that a ten-pound shot would fall through the air ten times as fast as a one-pound shot.

The true principles of hydrostatics laid down by Archimedes were restored by Galileo with his experiments on floating bodies. Here he again refuted Aristotle's opinion that the sinking or floating of a body in water depended on its shape. Accurate knowledge of the specific gravity and water displacement of the human body now aids greatly in understanding differences in the floating ability of individuals.

Galileo dealt with practically every aspect of mechanics. He invented the telescope, helped devise the microscope, and wrote on problems of balance and the law of the lever. All but a fragment of his one treatise on the movement of animals has been lost. In writing on the interdependence of force and movement and in investigating the motion of projectiles, Galileo was preparing the way for Newton who was the first to formulate these observations into laws.

With the coming of Newton in 1642, the English people made their first contributions toward the future science of kinesiology. Sir Isaac Newton's life was that of an upperclass Englishman with no financial worries. He was schooled at Trinity College, Cambridge, receiving his bachelor's degree in 1665 and his master's degree three years later. Shortly afterwards he was offered the professorship of mathematics at Cambridge, and it was here he did his experimental work on gravitation, optics, and the laws of motion. The book, *Principia Mathematica Philosophiae Naturalis,* is his greatest work. In it he presents a system of mechanics resting upon foundations broad enough to serve for all subsequent developments in this field. Clear and logical are his three laws regarding resting and moving objects. As corollaries to the main laws, he presents various factors concerning falling bodies and uniformly accelerated motion. His concept of the parallelogram of forces is very applicable to a study of the angle at which muscles pull on the bones of the body.

Overlapping in life span with Newton is another Italian, Giovanni Alfonso Borelli, born of humble parents at Naples in 1608. Little is known of his early days, except that he studied mathematics in Rome at the Benedetto Castello. In 1640 he was invited to the chair of mathematics at the University of Messina where his fame grew so great and spread so far that in 1656, Ferdinand, Duke of Tuscany, invited him to teach at the University of Pisa. The years at Pisa were the brightest and most productive of his career. He was a pupil of Galileo in the sense that he read and learned greatly from Galileo's writings. Borelli was essentially a mathematician and a physicist. For his friends who were anatomists and physiologists, he wrote his greatest work, *De Motu Animalium,* because it gave him opportunity to apply his knowledge to new methods of research on the human body.

Borelli's treatment of movement established the more modern study of animal mechanics. For him, the various movements effected by the muscles presented two classes of problems: the specific problems, me-

chanical in nature, of the movements caused by particular muscles, and the general problem of the changes occurring within the muscle during contraction. In a chapter of *De Motu Animalium* called "Mechanical Propositions Useful for the More Exact Determinations of the Motive Power of Muscles," Borelli treats in succession the various problems of muscular mechanics encountered in the simple movements of flexion and extension, and the more complicated problems of standing, walking, running, and other forms of locomotion. He discusses the amount of force employed in producing movements of the body, and the loss which results from unfavorable mechanical action, resistance of the air, and resistance of the water. He went so far as to discuss the differences between tonic and voluntary muscular contraction.

Unfortunately, Borelli's intellectual genius was not supported by an amiable personality. He quarreled with his colleagues and envied the successes of others. Five years before his death, he was suspected of political conspiracy and for safety fled to Rome where he met the rather notorious Christina of Sweden who took him under her protection. It was she who finally paid for the publication of *De Motu Animalium* in 1680, a year after Borelli's death.

A century later three brothers, Ernst, Wilhelm, and Eduard Weber, grew up in Saxony, Germany. Not only were they capable mentally, passing through school rapidly; but they were robust physically, being strong wrestlers and untiring walkers. All of them studied in the medical sciences. Ernst, the oldest, occupied the chair of Physiology at Leipzig, and was soon joined by Wilhelm, nine years his junior. Having no laboratory space, these brothers began their research in the home of their father. When Eduard, thirteen years younger than Ernst, became prosector in anatomy at Leipzig, he joined the research. For more than thirty-five years the brothers worked together, becoming authorities in physiology, anatomy, and biomechanics.

Through his anatomical studies, Eduard showed the importance of atmospheric pressure in keeping the articular surfaces of the joints in apposition. He also accurately described the foot as a second-class lever.

The classical publication of Wilhelm and Ernst Weber, *Die Mechanic der Menschlichen Gehwerkzeuge* appeared in 1836. In it they discuss their observations of the mechanics of the stationary and moving body. By balancing their subjects on a board supported by a wedge, they improved upon Borelli's method of determining the distance of the center of gravity of the body from the sole of the foot. Considering the leg as a pendulum during movement, they described walking as "a movement of falling forward, which is arrested by advancing the passive limb and throwing the weight upon it." [10]

[10] Luigi Luciani, *Human Physiology*, translated by Frances A. Welby (Macmillan and Company, 1915) Vol. III, 114.

These brothers established the fact that in walking, the trunk and center of gravity sink to a lower level than in standing, and that this sinking is greater the longer the stride. In studying the relationship between the duration of a stride and its length, Wilhelm discovered that in running the duration of the step remained fairly constant with differences in velocity of the body being due chiefly to variation in the length of the stride. They were first to describe in chronological detail the movement of the center of gravity and the mechanics of walking, running, and other activities.

Difficulties were encountered in observing the joint action and muscular contractions of the moving body. Retinal mechanisms were not quick enough to catch each detail as it occurred. While the work of the brothers Weber was a definite advancement toward modern kinesiology, there came a standstill in its progress until a device to reproduce movement chronologically appeared. Thus, when Edward Muybridge and Etienne Jules Marey, pioneers in moving picture photography, began to record the activities of man and animals, kinesiology as it is known today had arrived.

Marey first applied the graphic method to the study of movement by equipping his subjects with shoes containing pressure-recording tambours in the soles. He used similar tambours on horses hoofs. Thus he was able to study walking on a level, walking up and downhill, running, and galloping.

Muybridge, subsidized by Governor Stanford of California, preceded Marey in photography by taking a series of instantaneous photographs of the gait of horses on a track in Palo Alto in 1878. A plaque at Stanford University today commemorates this important event. He placed a number of cameras, equipped with quick-acting shutters worked by an electro-magnet, at equal distances along the track. While running the horse successively broke a series of wires, each one setting free the shutter of a camera. His observations were extended to a study of the human body in motion. The illuminating photographs he took may now be viewed in the John Crerar Library in Chicago.

By taking a series of exposures on one photographic plate, Marey advanced a step beyond Muybridge. He went still further to develop "chronophotography on a ribbon." As director of the physiological station endowed by the city of Paris, Marey had unique opportunities for research in the field of movement. He studied extensively the movements of animals in their natural conditions, recording the swimming of fish and frogs, the flying of birds, and the walking, running, and swimming of man. His description of the action of the hind legs of a frog while swimming is clear and is in the form of a modern simplified kinesiological analysis. He wrote, "The animal flexes its legs, bringing them well under the body, then spreads them wide apart in such a manner that the two legs, directed laterally, form a right angle

with the axis of the body. Propulsion is effected by bringing the outstretched feet quickly together, after which they are gradually flexed and brought towards the body, and the series of movements recommences."[11]

To enhance the clearness of the photographs of men, Marey costumed them in black tights with shiny metal strips representing the shafts of long bones. This showed without confusion the postures of the upper and lower limbs, the head, hips and feet, and enabled complete cycles of events to be studied in greater detail than ever before.

Since the beginning of the twentieth century, great interest has been shown in the study of movement. Using frozen cadavers, Braune and Fischer were first to determine the center of gravity of the body in three planes. By dismembering the body, they found the center of gravity of each of its parts.[12] Later they applied this information to the living subject. Braune and Fischer pioneered in the study of the mechanics of biarticular muscles. They also improved Marey's method of photography by substituting bright Geisler's tubes for the metal strips on the subject's costume. By photographing the subject in several planes simultaneously, they were able to describe more accurately the movement of the various joints.[13]

Currently, people in all parts of the world are improving methods and progressing in detail, making kinesiology a definite science. To enumerate this research in detail would go beyond the purpose of this paper. Thus, only a brief statement is presented regarding some of the more important workers.

A. V. Hill in England has contributed greatly to the knowledge of the physiological changes occurring in the body during activity.[14, 15] T. K. Cureton, of Springfield College in Massachusetts, has applied his knowledge of physics in developing his analyses of track activities and swimming.[16] W. O. Fenn, working in conjunction with the Eastman Kodak Company, has used moving pictures in calculating velocities, kinetic energy, and muscular power put forth in movement.[17, 18] F. A. Hellebrandt, at the University of Wisconsin, is studying the

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11 E. J. Marey, "The Comparative Locomotion of Different Animals," *Smithsonian Report* (1893) 503.

12 E. A. Shafer, *Textbook of Physiology* (Macmillan Co., 1898) Vol. II, 258.

13 Luigi Luciani, *Op. cit.*, 115.

14 Archibald V. Hill, *Living Machinery* (Harcourt, Brace & Co., 1927).

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16 Thomas Kirk Cureton, Jr., "Mechanics of the Track Racing Start," *Scholastic Coach* (January 1935) 14; "Mechanics of Track Running," *Scholastic Coach* (February 1935) 10; "Mechanics of the Shot-Put," *Scholastic Coach* (March 1935) 9; "Mechanics of the High Jump," *Scholastic Coach* (April 1935) 15; "Mechanics of the Broad Jump," *Scholastic Coach* (May 1935) 8.

17 W. O. Fenn and C. A. Morrison, "Frictional and Kinetic Factors in the Work of Sprint Running," *American Journal of Physiology*, 92 (1930) 583–611.

18 W. O. Fenn, "Work Against Gravity and Work Due to Velocity Changes in Running; Movements of the Center of Gravity within the Body and Foot Pressure on the Ground," *American Journal of Physiology*, 93 (1931) 433–62.

physiology of posture, the movement of the center of gravity, and the muscular energy expended while maintaining the upright stance.[19-21]

Probably the best biodynamics laboratory of the present century is that of Nicolas Bernstein at the All-Union Institute of Experimental Medicine in Moscow.[22] Basler has done considerable in this field at the Sun Yatsen University in Canton,[23, 24] and Cotton has made fundamental contributions from the University of Sydney.[25] The cardiovascular aspects of the vertical stance have been especially studied by Jokl[26] in Johannesburg, Christensen[27] and his associates in Copenhagen, and by Mateeff[28-30] a Bulgarian investigator who introduced the term "gravity shock" within the physical education profession itself. Noticeable foci of interest have arisen in the classrooms of McCloy[31] at Iowa, Powell and Skarstrom[32] at Wellesley, and Sweigard[33] at New York University. Thus, much of the work started centuries ago is now being revived, revised, and developed by scientists with the emphasis on a study of movement to aid the physical educator in improving the working of the human machine.

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A Study of the Scholastic Attainments of Letter Winners at the State University of Iowa

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THE prominent part which intercollegiate athletics are playing in the programs of many educational institutions at the present time has stimulated discussions as to the effects of the athletic program on academic progress. Many of the questions can be answered by an expression of opinion only. It is difficult to decide whether the time and effort required to produce finished athletic teams compare favorably with the benefits derived, either by the participants or by the institution involved. Then also, some feel that finished athletes as a group tend to be inferior in both scholastic ability and interest. Also, some argue that the athletic program detracts from the academic progress of the institution.

In an attempt to answer some of the questions concerning athletes, a series of studies has been undertaken, which are related to the capabilities and achievements of athletes at the University of Iowa. This is a report of the first study in the series, and is an analysis of the scholastic attainment of the varsity award winners from September 1935 to June 1940.

The data used include the University of Iowa Qualifying and Placement Examination percentile rank, the grade point average, by semester, of each man, and the athletic success of each athletic team as measured by its conference standing. The use of the placement examination percentile made it necessary to eliminate the athletes who were migrants from other colleges or universities, from this study, since this information is available only on men who entered the Iowa State University as freshmen. The grades employed were secured from the Registrar of the University. The qualifying and placement percentiles were obtained from the chairman of the placement committee.

During the five-year period, 609 varsity awards were granted including ten sports. Twenty-two of these awards went to men who had migrated from other institutions, and therefore their records are not considered. The study involves 577 athletes and includes 432 major and 145 minor letter winners. They are distributed among the sports as follows:

Football	145	Golf	37
Basketball	69	Wrestling	36
Baseball	73	Gymnastics	35
Track and field	91	Cross country	16
Swimming	70	Tennis	15

Where grade point averages were calculated, the orthodox procedure was employed, which is as follows:

A=4 points	D=1 point
B=3 points	Fd=0 points
C=2 points	

Then by multiplying the grade weight of each course by the number of semester hours credit it carries, and dividing the total grade points by the number of hours involved, an average grade point is attained, the limits being zero to 4.00.

For the most part, the data presented are based on a combination of the scholastic attainments of both major and minor letter winners. In most cases, the small number of minor award winners, as compared to the major letter men, has little influence. In a few instances, where either major or minor letter winner averages are employed separately, it is so stated.

The raw data collected are omitted, because they are rather voluminous. Where data are required, summary tables are given.

The Scholarship of Letter Winners as Compared with Those of Other Men.—The scholastic attainment of letter winners is a topic of general interest. The data collected provide for comparing them with other male groups on the basis of scholarship. In Table I the grade point averages of letter winners over a period of five years are compared with those of all the undergraduate men in Liberal Arts and Commerce during the same periods. These groups were used because the athletes studied came chiefly from them. The all men's average for 1935–36 is omitted because the available figures included graduate students and were, therefore, not comparable.

TABLE I

Year	Liberal Arts-Commerce Average	Varsity Letter Winner Average	Difference
1935–36	....	2.10	...
1936–37	2.24	2.11	−.13
1937–38	2.22	2.16	−.06
1938–39	2.23	2.24	+.01
1939–40	2.22	2.20	−.02

The data show that during three of the years studied, the letter winners' averages were slightly below the Liberal Arts and Commerce men's averages in scholarship while for one year they were slightly above. It is also evident that the Liberal Arts-Commerce group average is fairly constant, while the averages of the athletes are definitely

upward. It seems to us that it is a worth-while project to include all the Big Ten conference schools in a study involving a comparison of the scholastic attainment of award winners with that of other comparable groups.

Placement Scores and Scholastic Attainment.—Each year, the University requires freshmen to take a placement examination. The percentile rank scores made by the letter winners are presented. In Table II the various teams are ranked according to their placement scores and compared with scholastic attainment for a five-year period.

TABLE II

	Placement Scores (percentile ave.)		Scholastic Ave.
Gymnastics	57.5	Gymnastics	2.47
Golf	54.0	Golf	2.28
Swimming	52.8	Wrestling	2.25
Cross country	52.3	Cross country	2.25
Track and field	47.0	Track and field	2.23
Tennis	46.1	Tennis	2.22
Basketball	44.2	Swimming	2.22
Wrestling	40.1	Baseball	2.14
Baseball	35.9	Basketball	2.01
Football	26.4	Football	2.01

These data show that six sports were ranked exactly the same by both the placement scores and scholarship. Gymnastics and golf are at the top by both methods of ranking, while football is at the bottom. Baseball varies one place on the placement test, being displaced by wrestling. The sports falling in between vary but little in both placement scores and grade points. The rank correlation between placement scores and scholarship rank is approximately .80.

A Comparison of the Scholastic Attainments of Letter Winners in Various Sports.— On the basis of the grade point average attained over a five-year period, the scholastic ranking of the letter winners is given in Table III.

TABLE III

Gymnastics	2.47	Tennis	2.22
Golf	2.28	Swimming	2.22
Cross country	2.25	Baseball	2.14
Wrestling	2.25	Basketball	2.01
Track and field	2.23	Football	2.01

The data show that gymnastics and golf stand at the top while baseball, basketball, and football are at the bottom. The other six sports vary only .03 of a grade point and are approximately equal to the men's average used for comparison. The only comment which we wish to make here is, that the three low sports play a more concentrated schedule and participate in a greater number of contests.

The Seasonal Factor in Scholastic Attainment.—For the most part, heavy competition in the various sports is confined to the second semester, the exceptions being football, basketball, and cross country. Table IV shows a comparison of the first and second semester grade points for the various sports over a five-year period.

TABLE IV

	First Semester	Second Semester	Difference
Cross country	2.38	2.12	−.26
Football	1.92	2.10	+.18
Basketball	1.99	2.02	+.03
Gymnastics	2.62	2.33	−.29
Swimming	2.25	2.19	−.06
Wrestling	2.29	2.17	−.12
Track and field	2.29	2.17	−.12
Golf	2.33	2.23	−.10
Tennis	2.26	2.10	−.07
Baseball	2.17	2.10	−.07

The data clearly show that the athlete suffers scholastically during the semester in which he is competing. In all sports, the grade point average, over a five-year period, is less during the semester in which varsity competition takes place. Football is a first semester sport, and the grade point average is less during the first semester. Basketball carries over from the first into the second semester, and the grade point average changes but little (+.03). The remainder are chiefly second semester sports, the result being a drop in scholarship for that semester.

Scholarship Trends Among Letter Winners.—An analysis of the data relative to the scholastic progress of letter winners over the past five years is shown in Table V.

TABLE V

Sport	'35–'36	'36–'37	'37–'38	'38–'39	'39–'40	Average
Football	1.98	1.85	1.93	2.19	2.14	2.01
Basketball	1.75	1.98	2.01	2.09	2.15	2.01
Baseball	1.80	2.23	2.18	2.29*	2.12	2.14
Track and field	2.22	2.21	2.33	2.16	2.12	2.23
Swimming	2.36*	2.02	2.15	2.25	2.31	2.22
Gymnastics	2.67	2.53*	2.41	2.43	2.36	2.47
Wrestling	1.87	2.20	2.44	2.38	2.31	2.25
Tennis	2.16	2.49	2.19	2.05	2.40	2.22
Golf	2.41	2.00	2.33	2.42	2.18	2.28
Cross country	2.33	2.18	...	...	...	2.25

* Indicates conference champions.

Although the grade point average for football athletes is well below average, there has been a definite improvement during the past two years. The scholastic average for this sport was 1.98 in 1935–36, reaching 1.85 in 1936–37 from which point it has improved, especially

in the last two years. It is evident that varsity football players have shown a marked improvement in scholarship.

In the case of basketball, the scholarship trend is definitely upward. It has increased, year by year, from 1.75 in 1935–36 to 2.15 in 1939–40.

Baseball players have shown no consistent trend in scholarship. During their championship year they were above average. Although they recovered from a poor showing in 1935–36 (1.80), they have been up and down scholastically.

Track and field athletes have been going gradually down since 1937–38 when they were well up in competition in the conference. Up until this time they were about average in scholarship.

The swimmers had a relapse in grade points following the year when they were conference champions. From this time on, they have been showing steady improvement in scholarship until last year when they were well above average.

The gymnasts maintained a grade point average well above average for the entire period studied. During the past five years the trend is downward, even though last year they were well above average.

In 1935–36, the wrestlers had a grade point average of 1.87. From this point on they have shown marked improvement, being well above average during the past three years.

The tennis and golf players are in and out scholastically, showing no general trend in scholarship. The small number of competitors and the lack of great emphasis on these sports prohibit the drawing of any conclusions about them.

In general, the data show that there has been a marked improvement in the scholarship of the football players, basketball players, swimmers, and wrestlers. There has been a definite downswing in track and gymnastics, while baseball, tennis, and golf showed no scholastic trends during the period studied.

Scholarship and Athletic Success.—It has been suggested many times that success in athletic competition goes hand in hand with good scholarship. During the past five years there have been some outstanding athletic teams which might be expected to rank higher than usual scholastically. A consideration of this point of view, on the basis of data collected, brings to light some interesting facts, shown by Table V.

A study of the progress of the football players shows that during the first three years of the five-year period studied, scholarship was at a rather low ebb, the highest grade point average being 1.98 with a low of 1.85. During this period only one conference win was attained, there being no wins during 1936–37 when scholarship was lowest. During the last two years of the period, the scholastic average showed a marked increase, which was accompanied by four wins in conference competition. The grade point averages of Iowa's "iron men" of 1939

were 2.14, which is a decided scholarship advantage over the losing teams. In fact the major letter winners in 1939–40 had a slight grade point advantage over any football team during the five-year period studied.

During the period studied, the baseball team shared the conference championship in 1937–38 and won it in 1938–39. During the championship year, the team had a higher grade point average than any other team during the period. For the preceding year when they were co-champions the major letter winners ranked next to the championship team in scholarship.

The swimming team won the conference championship in 1935–36. The grade point average for the team during this season was higher than for any other team during the period studied.

During 1939–40, the track and field team finished last in the conference. The grade point average of the letter winners for this period was the lowest during the past five years. This was especially true of major letter winners who had a grade point average of 1.91.

For the five-year period the track team ranked 5, 5, 3, 8, and 10 in conference indoor competition, and 6, 6, 5, 10, and 10 in outdoor competition. Their grade point averages for the period were 2.22, 2.21, 2.33, 2.16, and 2.12. When they were 3–5 in the conference their grade point average was highest and when they ranked 10–10 it was lowest.

A study of the records of letter winners in those sports where less emphasis is placed, when compared with scholastic success, shows the following: The gymnastic team did not win a conference meet during the five-year period studied except in 1936–37 when they were the conference champions. During this period their grade point average was 2.53 which is well above average. However, every other year, the gymnastic team's scholastic attainments were well above average, yet they failed to win a meet. There are no more than four conference schools maintaining conference gymnastic teams. The success of any of them seems to rest on one or two outstanding men. For these reasons the data are difficult to interpret.

The wrestling team data show that they were most successful in the conference when their grade point average was lowest. The team finished second in 1935–36 when their grade point average was lowest (1.98). Also, when their grade point average was highest (2.44) they made the poorest conference showing, finishing eighth.

The tennis team is a rather consistent loser, having never finished better than fifth, when eight schools supported teams. Except for two years, the tennis team's grade point attainment was below average, but during the years when they were well up in scholarship they failed to win.

Golf and cross country fall into the same category as tennis and gymnastics. Lack of consistent participation in cross-country and

lack of emphasis on golf make any conclusions which might be drawn unreliable.

In discussing the data presented we have purposely refrained from giving any speculative reasons for the conclusions drawn. There are a few points of explanation, however, which should be presented.

It must be remembered that letter winners are a selected group of university students. They are upperclassmen with no outstanding scholastic delinquencies. Where they made failures in courses, these failures were calculated in the grade point averages. The university men's group with which they are compared does include men who completely failed their work. Thus it might seem that we are comparing a group, from which wholesale failures are excluded with one which is loaded with them, thus arriving at a grade point average favoring the letter winners. Although we are dealing with a select group, we believe that the comparisons which we made are truly representative of the facts.

Another point to be recognized is that in measuring athletic success two methods were necessarily employed. In the case of tennis, track and field, golf, gymnastics, and swimming, conference standing is determined by a conference meet where all member schools compete at one time. In the case of football, basketball, and baseball, conference standing is based on dual competition, which means that every school does not compete with every other school in the conference each year.

CONCLUSIONS

The following conclusions are drawn from data collected over a five-year period 1935–40, from 577 letter winners at the University of Iowa:

1. The scholastic attainments of letter winners are approximately equal to the averages of the male group to which they belong.

2. The correlation between the ranks assigned by the placement scores and the grade point averages is approximately .80.

3. The sports upon which most emphasis is placed rank lowest in scholastic attainment.

4. Scholastic averages in all sports move down during the season of competition. This indicates that the time and effort required for training and competition causes the scholastic work to suffer.

5. In general, the scholastic attainments of letter winners at the University of Iowa are on the upgrade. This is especially true in football, basketball, and wrestling.

6. The data indicate that scholastic attainments and athletic success are directly related. This is shown by the fact that for the most part the scholastic attainments of letter winners during championship years either were the highest or well above the average of the group for the period studied.

Studies in the Rate of Learning Gross Bodily Motor Skills

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IT IS the purpose of this paper to present findings relating to individual differences in speed of learning gross bodily motor skills and the relation of these differences to tests of other physical traits and abilities.

This work has been motivated by the desire to find out why some individuals learn motor skills more rapidly than others. Ultimately we hope to be able to identify those traits or qualities which are basically involved in learning motor skills. If these factors can be identified it might be possible to develop tests or measurement procedures which would be valid measures of ability to learn motor skills. Such measures would make it possible to distinguish slow learners from fast learners, and, therefore, to be able to classify students into groups on the basis of their ability to learn motor skills. If the traits involved in learning motor skills can be identified it might be possible, by improving these traits, to improve ability to learn.

The approach to these problems now being reported will relate only to an explanation of the procedures that have been followed in attempts to secure measures of individual differences in speed of learning various sorts of motor skills, and to study the relationships between these individual differences and certain other factors, particularly the Brace Motor Ability and Iowa-Brace motor ability tests. The time now available will allow only for the briefest of explanations.

Two groups of studies will be reported. One study deals with scores on five skill events specifically devised and called learning tests. The other study deals with the learning of skills in a swimming pool. The original data used were secured by Misses Hander, Kirkner, and Dominy and Mrs. McNeely, in connection with their respective masters' theses. Much of the statistical computation was done by my assistant, Mr. C. E. McCarver.

FIRST GROUP OF DATA

The first group of data were obtained by recording the number of trials needed to perform perfectly five motor activities. The subjects were 275 high school girls. For these same subjects data on age, height, weight, strength, Brace Motor Ability, Iowa-Brace Motor Ability, athletic tests, other skill tests, teachers' ratings, physical education grades, I.Q., and previous experience were secured.

The first group of so-called learning tests were:

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1. Rhythm test. To perform a dance step, constructed for this purpose, correctly to count.

2. Field hockey tests. To score 12 points with 3 balls in driving at a target.

3. Tennis test. To bounce a tennis ball on racket for 10 consecutive bounces, while standing in a 3-foot circle.

4. Stunt test. To do a head- and handstand for 10 seconds, in any form.

5. Volleyball test. To bounce a volleyball against a wall with both hands 6 times in succession.

The score on each of these tests was the number of trials needed to pass the test. Scores on each test were converted into T-scores. T-scores were averaged to get the average learning score.

As would be expected, wide variations in individual differences were noted. Some girls passed the tests in few trials, others took many trials.

The question of whether or not these "learning tests" measured ability to learn the performances involved deserves considerable thought because on this point hinges much of the interpretation of results.

Zero-order correlations between "learning scores" and scores on other tests or items mentioned above were all positive but low. There was, however, marked relationship between Brace Motor Ability scores and rhythm test scores ($r = .50$). The highest correlation, .67, was found to exist between athletic ability (standing broad jump, 50-yard dash, baseball throw for distance) and average learning score. Age, height, weight, I.Q., strength, teachers' ratings, and physical education grades correlated little with learning scores. There appeared to be some relationship between previous experience and learning score.

Conclusions from these data would appear to indicate that either the so-called learning tests do not measure ability to learn or that the other measures obtained have little relationship to ability to learn motor skills. Since the highest correlations were found to exist between athletic ability and learning scores, it is quite possible that the learning tests measured acquired skill rather than ability to learn.

As a further study of the relationship between these factors, partial and multiple correlation studies were made. The average learning score has a multiple correlation of .92 against the five learning tests. Considering the average learning score, Brace motor ability, strength, athletic ability, Iowa-Brace motor ability, and skill test, a multiple correlation coefficient of .69 was obtained, with average learning score as the criterion score. The regression equation is: average learning score $= .14$ Brace $+ .00$ strength $+ .25$ athletic ability $+ .31$ skill test $+ 19.85$.

The correlation between athletic ability and average learning score is consistently reduced by the addition of the other factors.

The coefficient of multiple correlation between the Brace motor

ability$_0$, and the rhythm$_1$, hockey$_2$, tennis$_3$, stunt$_4$, and volleyball tests$_5$ was found to be, $R_{0\cdot12345}$=.59. It is interesting that the addition of any of the other learning tests reduced the correlation between Brace motor ability and rhythm tests from .50 to .46 but that the correlation consistently remained, being .46 to .47.

The coefficient of multiple correlation between athletic ability,[0] and rhythm,[1] hockey,[2] tennis,[3] stunt,[4] volleyball [5] was $R_{0\cdot12345}$=.80. The regression equation weightings are: athletic ability = .61 rhythm + .59 hockey + .28 tennis + .44 stunt + .42 volleyball + 18.02.

This multiple coefficient is a fairly significant indication that the learning tests are measuring acquired general athletic ability rather than ability to learn motor skills. The correlation between athletic ability and headstand remains low regardless of the addition of the other tests, an interesting result.

Although instructors' judgment ratings were supposed to be ratings of ability to learn motor skills, there is evidence that the thing they were rating was really athletic ability.

This is shown by a coefficient of multiple correlation, $R_{0\cdot12345}$ = .64 where the variables are: teachers ratings$_0$, learning score$_1$, Brace$_2$, Iowa-Brace$_3$, athletic ability$_4$, and strength$_5$. The zero-order correlation of .59 between teachers' ratings and athletic ability is raised only to .64 when the other variables are kept constant. It is also quite apparent that the teacher ratings were not made on the factors measured by the strength test, the Brace, or Iowa-Brace motor ability tests since the correlations are invariably low regardless of other variables.

As a summary of this part of the study the following tentative conclusions are offered.

1. The plan of measuring speed of learning in terms of the number of trials required to master a skill test is worthy of further study. Other studies under way will hold the number of trials constant and measure increments of improvement, and will equalize previous experience.

2. The "learning tests" measure individual differences of some sort.

3. There was little correlation between the "learning tests" and age, height, weight, I.Q., strength, motor ability, teachers' ratings, and teachers' grades.

4. There was substantial correlation between average learning score and athletic ability as measured.

5. A coefficient of multiple correlation of .80 was found between athletic ability and the five learning tests.

6. Indications are that the learning tests are measuring general athletic ability rather than ability to learn motor skills quickly.

7. If the learning tests used in these studies really measure ability to learn, the only factors having much significant relationship to them are measured by the athletic tests; namely, dash, jump, and baseball throw.

THE SECOND STUDY

The second group of data studied involved motor skills related to swimming; and age, height, weight, I.Q., Brace motor ability, Iowa-Brace motor ability, McCloy's classification index, number of times in the pool, and other swimming tests passed. The subjects were 89 girls, in grades 6, 7, and 8, all of whom were beginning swimmers and were selected from a group of 206 girls.

The learning tests in this case consisted of the following:

1. Hold the breath for 20 seconds under water.
2. Face float, change to back float, and stand, covering 15 feet.
3. Rhythmical breathing 15 times, exhaling under water.
4. Push off on back, glide 10 feet and change to face float.
5. Tread water 30 seconds.
6. Surface dive and swim between partner's legs.
7. Flutter kick 25 feet.
8. Handstand for 5 seconds in shallow water.
9. Jump into deep end, level off, swim 25 feet, and return.
10. Go 30 feet in 3 strokes with elementary back stroke.

The number of trials required by each girl to pass each of these tests was recorded. The scores on each test were scaled and an average T-scale score for each girl was obtained. This score is called the average learning score. It represented the number of trials required to learn the ten test items.

Here again wide variation in individual differences were noted although some of the learning tests were too easy and showed undistributed scores.

Zero-order correlations between average learning scores and

Brace motor ability	=	.32
Iowa-Brace M.A.	=	.27
Other tests passed	=	.37
I.Q.	=	.17
Height-weight combination	=	.52

Brace motor ability correlated with:

Iowa-Brace M.A.	=	.39 (this is usually about .80)
Other tests passed	=	.42
I.Q.	=	−.16
Height-weight	=	−.11

Other intercorrelations were smaller.

With average learning scores as criterion scores against Brace M.A.$_1$, Iowa-Brace M.A.$_2$, other tests passed$_3$, I.Q.$_4$, and height-weight$_5$, a coefficient of multiple correlation of .65 was obtained.

The only significant coefficient found is that between average learning score and the height-weight combination. This coefficient remains about .55 regardless of the addition of other variables. It is quite possible that the height-weight ratio measures buoyancy to some extent.

A coefficient of multiple correlation of .49 between Brace motor ability and Iowa-Brace, height-weight, and average learning score as variables was obtained. This would indicate that the zero-order correlation of .32 between Brace motor ability and average learning score was little affected by the other variables.

When specific age groups were studied and when students were equated as to number of times in the pool, coefficients of .47 and .48 were obtained between Brace motor ability and average learning scores.

Conclusions from study of swimming skills are:

1. Individual differences were found in the number of trials required by beginning swimmers to learn selected swimming skills.

2. I.Q. is not a significant factor involved in speed of learning motor skills in water.

3. The Brace motor ability test is slightly better than the Iowa-Brace test as a measure of ability to learn motor skills in water, but neither of these tests can be used as a predictive measure of ability to learn motor skills in water as measured in this study.

4. Findings indicate fair relationship between height-weight ratio and learning scores.

As a general summary the following tentative conclusions are offered.

1. Learning scores consisting of the number of trials required to learn gross bodily motor skills may be measures of ability to learn but proof of this is insufficient.

2. There is significant evidence that the learning tests used measure general athletic ability rather than ability to learn, or motor educability.

3. It is suggested that buoyancy may be a significant factor in ability to learn motor skills in water.

4. If the learning tests studied are valid measures of ability to learn, there is some indication that the Brace motor ability test and the Iowa revision of this test measure motor educability; but the data indicate that neither of these tests have predictive value, and no proof has been produced that these tests are tests of motor educability.

5. It should be noted that reliabilities of the learning tests have not been established.

The Respiratory Habits of Trained Swimmers During the Start of a Race

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IN ORDER for the coach to be able to explain to his swimmers how the respiratory mechanism functions during the start of a race, he must know the habits of trained swimmers as well as the factors in respiration which contribute to speed at the start.

Felker[1] studied the respiratory habits of trained and untrained track runners and found that, after the first few trials, both groups breathed normally between the commands, "On your marks" and "Get set," while at the command, "Get set," they held their breath in a normal inspiration until the gun was fired.

The experiment reported in this study was designed to determine the respiratory habits of trained swimmers during the start of a race, and to compare the respiratory habits of trained swimmers with those of trained track runners.

The respiratory habits of six varsity swimmers on the State University of Iowa swimming team were studied. Several records of breathing movements were taken from each man, using a pneumograph which was connected by thick-walled rubber tubing to a tambour. A stylus attached to the tambour marked on the smoked paper of a slowly moving kymograph. An interval timer was arranged to record the time in one-fifth seconds. A signal marker was used to indicate the incidence of the starting commands.

The start was the same as that taken under ordinary racing conditions. An experienced starter gave the commands, "Swimmers ready," and "Take your marks." After the swimmer stepped to the starting mark and assumed his customary starting position, the pistol was fired after a steady balance was maintained for an appreciable length of time. At the pistol shot, the swimmer left his mark.

The experimenter grasped the rubber tubing leading from the pneumograph so that as the swimmer left his mark, the tubing slipped off the end of the pneumograph and the record was terminated.

THE DATA

The data show that during the time elapsing between the commands "Swimmers ready" and "Take your marks," the trained swimmers either

[1] Arnold H. Felker, "A Study of the Respiratory Habits of Sprinters in Starting a Race," SUPP. TO RES. QUART., 5:1 (March 1934) 20–26.

breathed normally or breathed rapidly and deeply. During the interval between the command "Take your marks" and the moment the swimmers had assumed a steady balance in their starting positions, those swimmers who were breathing normally before the command "Take your marks" continued to breathe normally, and those swimmers who were using forced respiration either continued to breathe rapidly and deeply or reduced their respirations to normal or sub-normal.

The respirations of nearly all swimmers ended with a normal inspiration as they assumed a starting position. Between the moment at which the swimmer assumed a steady balance in the starting position and the moment at which the pistol was fired, all the trained swimmers ceased respiration and held their breath in inspiration. As each swimmer became "set" in the starting position he completed the phase of respiration which he was undergoing and then stopped his breathing at the end of a normal inspiration. If he assumed the "set" position while he was at the end of a deep inspiration, he would exhale slightly and then hold his breath. If he was at the end of an expiration as he reached the "set" position, he would inhale slightly before holding his breath. All trained swimmers held their breath in the inspiratory phase while "set" in the starting position awaiting the pistol shot.

After the pistol was fired the movements of the swimmer obliterated a further record of the respirations. However, most trained swimmers were observed to take a deep inhalation as they left their marks. A typical record of the respiratory response of a trained swimmer is reproduced in FIG. I.

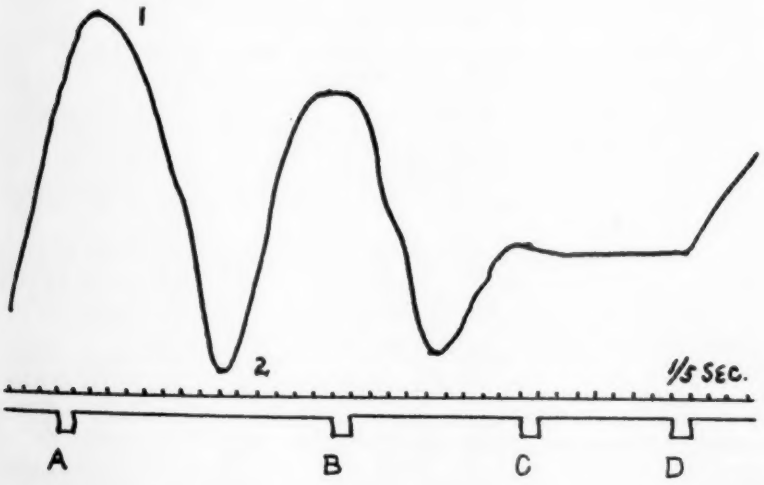

FIG. I. Respiration of swimmers during the start. A, "Swimmers ready"; B, "Take your marks"; C, "Set"; D, pistol shot. 1, inspiration; 2, expiration.

DISCUSSION

The practice of forced respiration during the period that preparations are being made for the start of a race is observed in many trained swimmers. This overventilation serves to reduce the tension of carbon dioxide in the alveolae and improves performance by facilitating breath holding during the glide underwater and the first few strokes of the race.

If conditions were such that forced respiration could be continued until the moment before the swimmer entered the water, the beneficial effects of overventilation would be augmented. However, in order to maintain his equilibrium in a delicately balanced starting position while awaiting the pistol shot, the swimmer must halt the heaving movements of his thorax which accompany forced respiration.

In addition to aiding the swimmer to maintain a steady balance in the "set" position, cessation of respiration also aids the swimmer to give maximum attention while waiting for the pistol shot.

If a swimmer frequently loses his balance while in the starting position or is a slow starter, the coach may check the swimmer's breathing habits to find if he is properly holding his breath in the starting position while awaiting the pistol shot.

The short and deep inhalation at the take-off acts to increase the swimmer's buoyancy and prevents him from sinking too deep during the plunge and glide. It also provides him with air which further aids him to hold his breath without distress during the glide and the first few strokes.

CONCLUSIONS

A study of the respiratory habits of trained swimmers during the start of a race supports the following conclusions:

1. Prior to the starter's command, "Take your marks," trained swimmers either use forced respiration or breathe normally. After the command "Take your marks," as the swimmers assume the starting position and maintain a steady balance while awaiting the pistol shot, the breath is held at the end of a normal inspiration. After the pistol shot, as the swimmers prepare to leave their marks, a deep inspiration is made and is held.

2. The respiratory habits of trained swimmers are similar to those of trained track runners. The adaptation of respiratory habits to race situations is, in most cases, so natural that the athlete acquires proper habits through practice and without the aid of a coach.

Acknowledgment.—The author wishes to thank David A. Armbruster, Swimming Coach, and W. W. Tuttle, Professor of Physiology, for their assistance in carrying out this investigation.

An Investigation of the Present Status of Social Hygiene Education in the Minnesota Public Schools*

By William Griffiths

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WITHIN the last year the Minnesota Department of Health, in cooperation with the Minnesota Department of Education, instituted an educational program in social hygiene. Before an attempt was made to help the public school districts enlarge their social hygiene programs, it seemed desirable to make a careful study of the present status of sex education in the Minnesota public schools. This report is published in the belief that it may help other states which are attempting similar educational programs.

PROBLEM

The purpose of this study was to learn the extent and nature of social hygiene education in the Minnesota public schools, and the attitudes of school superintendents toward sex teaching in the school curriculum.

According to the "Minnesota Educational Directory" for 1939–40, there are approximately 500 school districts in the State of Minnesota. Questionnaires were sent to 500 school superintendents requesting that the forms be filled out and returned as quickly as possible. A letter accompanying each questionnaire explained the nature of the investigation and the resasons for the study. The letter was signed by the Executive officer of the State Board of Health and the Minnesota State Commissioner of Education. A month after the questionnaire was mailed, a second letter was sent to those superintendents who had made no return. Of the 500 questionnaires sent, 384 were returned. This study is based on 370 questionnaires; 14 were discarded, either for incompleteness or failure to follow instructions.

The questionnaire consisted of four questions:

Question 1. The first question listed 33 social hygiene topics and requested the superintendent to indicate after each topic the degree to

*Abstract from Minnesota Department of Health pamphlet of same title, September, 1940.

which it was covered in the entire curriculum by encircling one of the key numbers.

0 Topic not covered at all
1 Topic only briefly mentioned
2 Topic covered fairly well
3 Topic covered rather completely
4 Topic covered very completely

The superintendent was also asked to list the grades in which the subject was taught, and after each grade to name the department teaching the topic.

The 33 social hygiene topics used in this study were chosen from a larger list. Those topics selected for final use were ones which were most frequently suggested by social hygienists as topics which might be included in the public school curriculum.[1,2,3,4,5,6,7,8]

Question 2. In the second question the superintendent was asked to state whether he felt his present program in social hygiene education was satisfactory.

Question 3. If the answer to the above question was negative, he was asked to give reasons why his program was unsatisfactory.

Question 4. This question read: "Do you feel that the colleges, especially the teachers colleges, should offer courses to the students on principles and methods of teaching social hygiene in the public schools?"

RESULTS

Question 1—Part A: Extent to which topics were covered in entire curriculum. Table I shows the percentages of total schools covering topics in the entire curriculum. It may be seen that a high percentage of the schools either did not cover most of the topics at all or only briefly mentioned them, and that only a few schools either covered topics rather completely or very completely. Eight topics were not covered at all by 50 per cent or more of the schools, and if to this are added those only briefly mentioned, 24 or nearly three-fourths of the topics were either not covered at all or only briefly mentioned by 50 per cent or more of the schools. If 75 per cent of the schools be taken as the criterion, it is found that one-third of the topics were either not covered at all or only briefly mentioned by 75 per cent or more of the schools. Table I reveals that only one topic, reproduction in various forms of living things, was covered very completely by as much as 25 per cent of the schools.

The list of 33 social hygiene topics was given to five public health physicians and five public health nurses who were asked to classify each under one of four general social hygiene divisions according to the group in which the topics fit most naturally with regard to subject matter. The four divisions were: General Biology; Anatomy and Physiology; Psychology and Sociology; and Personal and Social Health.

TABLE I

PERCENTAGES OF 370 SCHOOLS COVERING TOPICS IN ENTIRE CURRICULUM

Topics	Not Covered At All	Only Briefly Mentioned	Covered Fairly Well	Covered Rather Completely	Covered Very Completely
1. Anatomy of female generative organs	52	34	10	3	1
2. Anatomy of male generative organs	48	34	12	4	2
3. Boy and girl friendships	27	30	26	12	5
4. Caution against quackery	29	25	21	15	10
5. Child care and training	32	20	21	18	9
6. Direction of new interests at adolescence	50	25	16	7	2
7. Heredity and eugenics	9	13	27	32	19
8. History of the family	9	19	35	25	12
9. Human embryology	40	30	19	8	3
10. Human fertilization	49	25	13	8	5
11. Hygiene of adolescence	34	32	22	10	2
12. Ideas of manliness and womanliness	19	25	34	15	7
13. Importance of good habits	8	17	31	29	15
14. Importance of family for individual and society	10	15	33	27	15
15. Masturbation	79	14	4	2	1
16. Menstruation	49	25	13	8	5
17. Mental hygiene	16	27	29	21	7
18. Petting	50	28	14	6	2
19. Physical changes at adolescence	31	34	23	9	3
20. Physiology of the reproductive organs	46	34	12	7	1
21. Postnatal development (physical growth)	50	23	16	8	3
22. Pregnancy	67	17	8	6	2
23. Prenatal development	49	28	15	6	2
24. Preparation for adolescence	58	22	13	6	1
25. Preparation for marriage	34	25	24	13	4
26. Prostitution	49	27	13	9	2
27. Purpose of the family	8	16	35	28	13
28. Reproduction as one of the basic life processes	3	15	32	29	21
29. Reproduction in various forms of living things	1	10	31	33	25
30. Responsibilities of marriage	27	25	27	15	6
31. Seminal emissions	84	9	4	2	1
32. Venereal disease	23	36	22	15	4
33. Wholesome attitude toward sex	27	27	24	16	6

The amount of agreement among the judges was very high except for two topics. Additional judges were secured for these two topics until a two-thirds agreement was obtained as to the most appropriate division.

An analysis was then made in order to discover the extent to which the topics were taught in the curriculum according to these four general divisions. Table II gives the number of schools covering at least one of the topics in a particular division. For example, 116 schools covered at

least one topic in the Anatomy and Physiology division rather completely or very completely, as compared to 262 schools that covered at least one topic rather completely or very completely in the General Biology division.

TABLE II

EXTENT TO WHICH SCHOOLS COVERED AT LEAST ONE TOPIC IN A PARTICULAR DIVISION (N = 370)

Divisions	Number of Schools Covering at Least One Topic: Either not at all or only briefly mentioning it	Fairly well	Either rather completely or very completely
Anatomy and physiology	359	202	116
General biology	122	192	262
Personal and social health	356	248	211
Sociology and psychology	355	316	239

Also, 359 schools covered at least one topic in the Anatomy and Physiology division either not at all or only briefly mentioning it. From this table it may be seen that the topics in the General Biology division were covered most adequately, then the topics in the Personal and Social Health and Sociology and Psychology divisions, and least adequately, those topics in the Anatomy and Physiology division.

One question which this study attempted to answer was whether there was a relationship between school districts of various sizes and the amount of social hygiene taught. The schools were divided into three groups according to the size of enrollment. Table III gives the three groups with the number of schools in each and the range of enrollment.

TABLE III

SCHOOLS CLASSIFIED ACCORDING TO ENROLLMENT

	No.*	Enrollment Range
Small enrollment	281	to 500
Middle size enrollment	52	500 to 1,000
Large enrollment	33	over 1,000

*On four questionnaires the names of schools were omitted.

From Table IV it may be seen that there is a general tendency for the schools with the large enrollment to teach the social hygiene topics to a greater extent than the schools with the middle size and small enrollments. In interpreting Table IV it may be said that 11 topics were not covered at all by 50 per cent or more of the small schools; 9 topics not covered at all by 50 per cent of the middle size schools; and 5 topics not covered at all by 50 per cent or more of the large schools. Striking differences are noted when the criterion of 75 per cent or more of the schools either not covering topics at all or only briefly mentioning them, is taken. Only two topics are either not covered at all or only briefly

TABLE IV
PERCENTAGE GROUPINGS OF TOPICS COVERED ACCORDING TO ENROLLMENT GROUPS

Small Enrollment: N = 281 Middle Enrollment: N = 52 Large Enrollment: N = 33 Topics	50% or More of Schools Not Covering Topic at All			50% or More of Schools Either not Covering Topic at All, or Only Briefly Mentioning It			75% or More of Schools Either not Covering Topic at All, or Only Briefly Mentioning It			25% or More of Schools Either Covering Topic Rather Completely or Very Completely		
(Enrollment groups)	S	M	L	S	M	L	S	M	L	S	M	L
1. Anatomy of female generative organs	X	...	...	X	X	X	X	X	...	...	...	...
2. Anatomy of male generative organs	X	X	...	X	X	X	X	X	...	...	...	...
3. Boy and girl friendships	...	...	...	X	...	...	...	...	...	...	...	X
4. Caution against quackery	...	...	...	X	X	...	...	...	...	...	X	X
5. Child care and training	...	...	...	X	...	...	...	...	...	...	X	X
6. Direction of new interests at adolescence	X	X	...	X	X	X	X	X	...	...	...	X
7. Heredity and eugenics	...	...	...	...	...	...	...	...	...	X	X	X
8. History of the family	...	...	...	...	...	...	...	...	...	X	X	X
9. Human embryology	...	...	...	X	X	X	...	X	...	...	...	...
10. Human fertilization	...	...	...	X	X	X	...	X	...	...	...	X
11. Hygiene of adolescence	...	...	...	X	X	...	...	...	...	...	...	X
12. Ideas of manliness and womanliness	...	...	...	...	...	...	...	...	...	...	X	X
13. Importance of good habits	...	...	...	...	...	...	...	...	...	X	X	X
14. Importance of family for individual and society	...	...	...	...	...	...	...	...	...	X	X	X
15. Masturbation	X	X	X	X	X	X	X	X	X	...	...	...
16. Menstruation	X	...	...	X	X	...	X	...	...	...	...	X
17. Mental hygiene	...	...	...	...	...	...	...	...	...	X	X	X
18. Petting	X	...	...	X	X	X	X	...	...	...	...	X
19. Physical changes at adolescence	...	...	...	X	X	...	...	...	...	...	...	X
20. Physiology of the reproductive organs	...	X	...	X	X	X	X	X	...	...	...	...
21. Postnatal development (Physical growth)	X	X	...	X	X	X	X	...	...	...	...	X
22. Pregnancy	X	X	X	X	X	X	X	X	...	...	...	...
23. Prenatal development	X	X	...	X	X	X	X	X	...	...	...	...
24. Preparation for adolescence	X	X	X	X	X	X	X	X	...	...	...	...
25. Preparation for marriage	...	...	...	X	X	...	...	...	...	...	...	...
26. Prostitution	...	...	X	X	X	X	X	X	...	...	...	...
27. Purpose of the family	...	...	...	...	...	...	...	...	...	X	X	X
28. Reproduction as one of the basic life processes	...	...	...	...	...	...	...	...	...	X	X	X
29. Reproduction in various forms of living things	...	...	...	...	...	...	...	...	...	X	X	X
30. Responsibilities of marriage	...	...	...	X	X	...	...	...	...	...	...	X
31. Seminal emissions	X	X	X	X	X	X	X	X	X	...	...	...
32. Venereal disease	...	...	...	X	X	...	...	...	...	...	...	X
33. Wholesome attitude toward sex	...	...	...	X	...	...	...	...	...	...	X	X
Totals	11	9	5	24	21	14	13	12	2	8	12	22

mentioned by 75 per cent or more of the large schools, compared to 13 and 12 topics for the small and middle size schools. It is also interesting to note how many more topics are covered either rather completely or very completely by the large schools than by the other two enrollment groups.

Part B: Grades in which topics were taught.

From a general inspection of Table V it would appear that most of the social hygiene teaching is done in the ninth, tenth, and twelfth grades. In order to state more exactly in what grades most of the teaching was done, an analysis of variance was applied to the single grade data of Table V. By so doing the following table of analysis was obtained:

Variation	D F	Sum of squares	Mean square
Between grades	5	84479	16895.8*
Between items	32	9181	286.9
Remainder	160	34112	213.2
Total	197	127772	

* Highly significant.

From this it is apparent after an application of a test of significance that the variation between the grades was highly significant, whereas that between the items was insignificant. The nature of variation between the grades can be seen by examining the mean values obtained from each of the single grade columns in Table V. These are:

Grade	7	8	9	10	11	12
Mean value	7.90	10.2	28.2	69.3	18.0	33.4

The greatest percentage of schools teach social hygiene in grades ten, twelve, and nine, the greatest majority being in the tenth grade.

Some schools teach a particular topic in more than one grade. Table V gives the most frequent of the grade combinations; as may be seen topics are most often taught in the combination, tenth to twelfth grades.

Part C: Departments in which topics were taught.

From Table VI it may be observed that most of the teaching of social hygiene is done in Biology, although the Departments of Physical Education, Home Economics, and Social Science are doing a good amount. Approximately one-half of all the topics are taught to a greater extent in Biology than any other single department.

It has long been recognized that girls have received more social hygiene education in the schools than boys. This was again brought out in the investigation although sex differences were not directly studied. In very few cases do boys receive instruction from the Home Economics Department or from the school nurse.

TABLE V.
PERCENTAGES OF SCHOOLS TEACHING TOPICS IN VARIOUS GRADES
Grades in Which Topics Were Taught

TABLE V

PERCENTAGES OF SCHOOLS TEACHING TOPICS IN VARIOUS GRADES

Topics	Grades in Which Topics Were Taught										
	Single Grades*							Grade Combinations			
	No.	7	8	9	10	11	12	1–12	7–12	7–9	10–12
1. Anatomy of female generative organs	192	2	3	20	91	13	11	.....	1	1	8
2. Anatomy of male generative organs	179	3	2	20	93	13	12	.....	1	1	8
3. Boy and girl friendships	270	16	22	51	66	37	46	1	6	7	22
4. Caution against quackery	263	11	16	33	69	23	41	.....	4	5	14
5. Child care and training	253	7	11	35	69	22	33	1	2	3	12
6. Direction of new interests at adolescence	183	8	13	26	35	8	13	.....	1	5	4
7. Heredity and eugenics	336	2	2	10	63	18	60	.....	1	1	15
8. History of the family	338	4	5	14	54	22	12	.....	.....	1	7
9. Human embryology	223	.....	1	8	88	5	9	.....	.....	.....	3
10. Human fertilization	210	5	6	25	93	9	10	.....	1	1	5
11. Hygiene of adolescence	244	13	18	47	84	15	17	.....	2	10	9
12. Ideas of manliness and womanliness	299	23	26	52	70	37	49	4	11	9	20
13. Importance of good habits	339	25	26	52	75	32	46	4	12	8	17
14. Importance of family for individual and society	333	2	3	11	32	15	76	1	1	1	10
15. Masturbation	77	13	18	36	75	21	26	.....	4	8	9
16. Menstruation	189	17	25	63	86	20	19	.....	.....	11	10
17. Mental hygiene	311	17	10	33	68	23	43	2	7	7	12
18. Petting	183	8	16	42	64	34	46	.....	3	4	23
19. Physical changes at adolescence	253	9	13	39	85	13	13	.....	2	6	8
20. Physiology of the reproductive organs	199	5	6	25	91	13	12	.....	3	3	8
21. Postnatal development (physical growth)	185	4	6	17	81	13	16	.....	1	2	5
22. Pregnancy	123	4	5	27	80	19	21	.....	.....	4	12
23. Prenatal development	189	2	3	13	85	12	15	.....	1	1	6
24. Preparation for adolescence	157	17	21	45	66	11	27	.....	3	10	6
25. Preparation for marriage	244	1	2	13	41	15	63	.....	1	1	7
26. Prostitution	188	2	3	8	26	12	79	.....	1	2	6
27. Purpose of the family	341	3	4	11	37	13	74	1	1	1	10
28. Reproduction as one of the basic life processes	358	2	3	28	92	6	7	.....	1	2	3
29. Reproduction in various forms of living things	364	2	4	26	93	6	6	.....	1	1	2
30. Responsibilities of marriage	270	1	2	12	36	14	69	.....	1	1	8
31. Seminal emissions	56	14	20	38	75	21	29	.....	5	7	11
32. Venereal disease	286	2	3	12	50	16	63	.....	1	1	10
33. Wholesome attitude toward sex	270	17	19	38	73	30	38	3	9	6	16

* A particular topic may have been taught in more than one grade.

TABLE VI

PERCENTAGES OF SCHOOLS TEACHING TOPICS IN VARIOUS DEPARTMENTS

Topics	Departments in Which Topics Were Taught*											
	No.	Home Room	Biology	Phy. Ed.	Home Ec.	Social Sc.	Gen. Sc.	Health Ed.	Nurse	Physiology	Guidance	Misc.
1. Anatomy of female generative organs	192	1	76	15	14	2	5	2	2	1	.....	1
2. Anatomy of male generative organs	179	.....	81	15	7	2	7	2	1	1	.....	2
3. Boy and girl friendships	270	11	11	15	32	23	4	1	1	1	6	12
4. Caution against quackery	263	3	49	9	16	28	15	1	1	1	2	7
5. Child care and training	253	.....	23	2	63	13	2	1	7	.....	1	1
6. Direction of new interests at adolescence	183	4	30	25	20	15	8	1	1	1	1	4
7. Heredity and eugenics	336	.....	59	1	7	61	9	1	.....	.....	1	1
8. History of the family	339	.....	23	1	12	76	4	.....	.....	.....	1	1
9. Human embryology	223	.....	79	1	16	3	3	1	3	.....	1	1
10. Human fertilization	210	1	76	13	10	2	9	2	2	.....	1	1
11. Hygiene of adolescence	244	1	49	37	21	4	8	3	2	1	1	2
12. Ideas of manliness and womanliness	299	7	18	23	25	23	6	2	1	1	6	14
13. Importance of good habits	339	4	45	20	18	27	20	4	1	1	2	13
14. Importance of family for individual and society	333	.....	20	2	10	75	3	1	.....	.....	1	1
15. Masturbation	77	3	26	48	21	3	.....	4	5	.....	3	3
16. Menstruation	189	1	21	55	37	2	2	2	4	.....	1	1
17. Mental hygiene	311	3	44	15	18	32	12	4	1	1	2	9
18. Petting	183	8	12	14	34	21	2	2	1	1	6	9
19. Physical changes at adolescence	253	1	65	28	17	4	9	2	2	1	1	2
20. Physiology of the reproductive organs	199	1	72	16	13	2	5	3	4	1	1	1
21. Postnatal development (physical growth)	185	.....	55	1	41	4	3	1	6	.....	1	.....
22. Pregnancy	123	1	39	20	39	4	1	2	7	1	1	1
23. Prenatal development	189	.....	65	1	33	4	2	1	6	.....	1	1
24. Preparation for adolescence	157	3	34	12	24	15	7	2	1	1	1	3
25. Preparation for marriage	244	1	15	3	32	60	1	1	1	.....	1	1
26. Prostitution	188	1	16	3	10	78	3	.....	1	.....	1	2
27. Purpose of the family	341	.....	20	2	14	74	4	.....	.....	.....	1	1
28. Reproduction as one of the basic life processes	358	.....	88	4	3	4	21	1	1	.....	.....	1
29. Reproduction in various forms of living things	364	.....	93	2	1	2	23	1	1	1	.....	1
30. Responsibilities of marriage	270	1	11	1	30	65	1	1	1	.....	1	2
31. Seminal emissions	56	.....	30	54	14	4	.....	5	5	.....	5	4
32. Venereal disease	286	1	35	9	11	59	2	1	1	.....	1	1
33. Wholesome attitude toward sex	270	4	43	17	25	26	6	4	2	1	3	10

The Home Economics Department teaches the following topics to a greater extent than any other department:

- Boy and girl friendships
- Ideals of manliness and womanliness
- Child care and training
- Petting

Other topics in which Home Economics does quite a deal of teaching are:

- Direction of new interests at adolescence
- Postnatal development
- Prenatal development
- Responsibilities of marriage
- Menstruation
- Pregnancy
- Preparation for adolescence
- Preparation for marriage

The interpretation can be made that until more boys either take courses in Home Economics or some new course is instituted for them, dealing with similar subject matter, they will be receiving insufficient training in many of these social hygiene topics.

Questions 2 and 3—To the question of whether the superintendents felt that their present program in social hygiene education was satisfactory or not, only 45 of the 370 remarked that their present programs were satisfactory. The great majority of the others listed one or more reasons why their programs were unsatisfactory. Table VII lists these alongs with the number of superintendents giving each reason. It may be seen that the most important single reason is that teachers have not been trained to teach social hygiene, although two other frequent reasons are that the community would not favor further teaching, and that schools are in need of course outlines and materials in social hygiene.

TABLE VII

REASONS FOR UNSATISFACTORY PROGRAMS IN SOCIAL HYGIENE

Reasons	No.
1. Teachers not trained to teach social hygiene	267
2. Community would not favor further teaching	176
3. Lack of materials, course outlines, etc.	64
4. Curriculum problem	20
5. Heterogeneous sex and age groupings	14
6. Courses not required by state	10
7. Parents need education before children	10
8. Other reasons	17

Question 4—The result found in Question 3, that the main reason why schools are doing so little in the teaching of social hygiene is because teachers have not been trained to teach the subject, has long been recognized as an important one. Question 4 asked the superintendents whether they thought colleges should offer to prospective teachers courses on principles and methods of teaching social hygiene in the

public schools. The reason this was asked on the questionnaire was that since Minnesota's primary approach to this whole problem of social hygiene education is through the teaching of courses in the teachers colleges and in private colleges, it was felt important to secure the reactions of school superintendents. By the close of 1941 courses in Social Hygiene Education will have been offered in all six of the state teachers colleges and two of the private colleges.

In Table VII are the responses of the superintendents to Question 4.

TABLE VIII

SUPERINTENDENTS' OPINIONS OF THE OFFERING OF COURSES IN COLLEGES ON SOCIAL HYGIENE TO PROSPECTIVE TEACHERS

No. = 370	Per Cent
In favor of colleges offering courses	89
Against colleges offering courses	3
Failed to answer question	8

It shows that the great majority of superintendents are in favor of having the colleges offer courses in social hygiene to prospective teachers. An analysis of the questionnaires of those superintendents who were against offering such courses revealed that for the most part they were ones who stated that they were against any teaching of social hygiene in the public schools.

INTERPRETATIONS

Before this investigation was undertaken, it was well realized that social hygiene teaching in the Minnesota Pubilc Schools was at a minimum. There was no exact record, however, as to the amount and nature of the teaching. This study attempted to show the particular regions of social hygiene education which were most neglected, also the departments and grades doing the most and the least teaching.

If social hygiene education is to be a continuous process taught in each grade, from elementary to senior high school levels, then it is hoped that this investigation will be of assistance to the instructors who teach college courses in social hygiene for prospective teachers, and those persons who work directly with the public schools in an attempt to enlarge their programs.

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The Endocrines and Exercise

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MOST of the early studies in relation to the endocrines and the effect of exercise involved a very simple procedure. The animals, almost always rats, were exercised in the Slonaker[1]* activity cage or some modification thereof, after a period of time killed, and the weight of the endocrine organs of the exercised animals compared with the inactive ones.

Slonaker's activity or revolving cage consisted of a large cylindrical drum 58.5″ in circumference made of $\frac{3}{16}$″ wire mesh which revolved on a stationary axle. On the axle was fastened the nest box and food and water pans. In his early cases described in the *Anatomical Record* of 1908, revolutions were recorded by means of kymograph. Seven years later he employed a cyclometer to measure revolutions. Slonaker's activity cage is of importance since it made possible studies concerning endocrines and exercise and has been adopted by many investigators as a means of measuring spontaneous activity.

Steinhaus[2] in 1932 used the medium of running and swimming in his study of the effect of these particular activities on the organ weights of growing dogs. In the case of running dogs, Steinhaus used a treadmill. This method of exercising animals is employed by many others but has not been found entirely satisfactory in the case of rats and cats. Cats are not inclined to run and rats are always in danger of receiving injuries.

Ingle, Moon, and Evans,[3] Gans and Miley,[4] and others have used the isolated gastrocnemius muscle as a means of measuring work performance in animals who are normal or who have been treated or untreated experimentally. The procedure includes the fixation of electrodes for the electrical (faradic) stimulation of the muscle which is working against a load of 100 grams or more. The stimulations are fixed per unit of time and may vary from 3 per second to 5 or more. With such a technique it is possible to stimulate the muscle to fatigue and, in noting the length of time required for fatigue and the height of contractions, to make comparisons between experimentals and controls.

Studies in regard to human subjects involve the use of the treadmill, ergometer, specifically controlled exercise, and clinical observations of pathological conditions.

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* Superior figures refer to numbered Bibliography at end of article.

Only within recent years have histological studies been made of the effect of exercise on endocrines. Knouff and his co-workers at Ohio State (unpublished) recently used this method in an attempt to correlate histological findings and chemical analysis of the lipid content of the cortex of the adrenals in rats exercised to exhaustion. Bensley[5] in 1914 observed histologically that the thyroid gland of the opossum when examined immediately after the arrival of the animal to the laboratory showed the normal type of gland. An examination two or three weeks later, however, disclosed a high degree of hypertrophy and hyperplasia.

In the review of the literature much of the work relating to the endocrines and exercise can be classified into the following categories:

1. Comparisons of the endocrine organs of the domesticated animal with those of the undomesticated in weight differences.

2. Comparisons in the weights of the endocrine organs of the exercised and non-exercised animal.

3. Extirpation of the endocrine organs with subsequent exercise and noting changes in activity. The animal frequently acting as his own control or compared with controls in such experiments.

4. Extirpation of the endocrine organs in both the controls and experimentals with or without therapy and noting the effect of therapeutic treatment on activity.

The most logical treatment of the subject of endocrines and exercise would be a discussion of each endocrine organ separately, inserting when necessary interrelations to other endocrines. It is impossible to discuss the effect of exercise on endocrines singly since their functions many times are interwoven with one another.

THE THYROID

Hatai[6] in 1914 investigated the weights of the endocrine glands of the wild Norway rat and the albino rat. He found no significant differences in the weight of the two types of rats when compared by sex and variety.

The same investigator[7] employing Slonaker's activity cage in 1915 studied the influence of exercise on the growth of organs in the albino rat. The rats were one month old when placed in the activity cage and exercised for a period of 3–6 months which is equivalent to 7 to 14 years in the span of human life. When the controls were compared with the experimentals after the exercise period he noted a difference of nearly 13.44 per cent in the weight of the thyroid in favor of the controls.

Steinhaus, Hoyt, and Rice[8] in their experiment with growing dogs mentioned previously found an increase in the weight of the thyroids of the runners of 20 per cent while the swimmers showed an increase of 34 per cent. Since in all experiments such as these mentioned the

average weights are cited, the work of these investigators does not substantiate the results given by Hatai on the effect of exercise on the weight of the thyroid.

Hoskins[9] in 1927 found on the removal of the thyroid of the rat that the activity, as measured by the revolving cage method, was not decreased. Wang and Richter[10] using the same method of measuring activity substantiated the results of Hoskins. Wang[11] and Hoskins[12] in the same year found that feeding dessicated thyroid to thyroidectomized rats did not give the anticipated increase in activity.

Richter [13] in 1933 decided to investigate the results observed by the above investigators and repeated much of their work. His study included extirpation of the thyroid in rats, feeding of dessicated thyroid, and an extension of the experimental period to facilitate an observation of food and water intake, body weight, and sex gland activity.

The change in activity produced by thyroidectomy gave widely different results. Some of the animals showed no effect while in others there was a moderate decrease in activity. On autopsy 7 of the 13 experimentals showed isolated fragments of tissue which Richter stated were not necessarily thyroid tissue. It is known that even a small piece of thyroid tissue is sufficient to maintain normal activity while complete removal or only microscopic traces produce a moderate reduction in bodily activity.

A point of interest and significance in Richter's experiment was the fluctuations which appeared in the regular cycles of activity of the completely thyroidectomized rat. The rats were active for 6–12 days and then became inactive for a period of 10–15 days. These cycles became more regular and distinguishable as the rats grew older.

Before thyroid feeding the activity of the thyroidectomized rats (4 males and 9 females) varied between 9,000 and 10,000 revolutions per day. On administration of the dessicated thyroid the activity dropped to a level of 500 revolutions per day and reached their normal level of 18,000–20,000 revolutions in 50 days.

The wide fluctuations and cyclic changes noted in Richter's experiment suggest that when the thyroid is removed the rhythm of some other gland exerts its influence. Under normal circumstances when the thyroid is intact it may act as a regulatory mechanism and would, therefore, keep the other gland in check and prevent the cyclic manifestation noted on thyroidectomy. Richter suggested that the pituitary, the adrenals, or the sex glands may rightly be suspected but the only evidence available at present to support this hypothesis is that changes actually do take place in the reproductive tract of the female rat simultaneously with the cyclic behavior. He noted that vaginal smears demonstrated a diestrus period during the inactive period and an estrus period during the active period.

Hall and Lindsay[14] raised the question of whether or not the in-

fluence of the thyroid hormone on activity might not be mediated by the maintenance of a normal level of metabolism. Since Magne, Mayer, and Plantefol [15] and Cutting and Tainter [16] have shown that dinitrophenol increased oxidation of cells by direct action in 1932, and it is possible to maintain the metabolic rate at desired levels by properly spaced doses, they decided to administer dinitrophenol to thyroidectomized rats to restore the normal level of metabolism and note the results on activity.

Hall and Lindsay[17] in a previous study in 1934 observed that dinitrophenol administered to normal animals decreased activity as measured by the revolving cage. Hall and Lindsay suggest that the depressing effect on activity may be the combined effect of dinitrophenol and thyroid extract (given in combination) acting together either on the basal metabolism or on other bodily processes.

In their later experiment with dinitrophenol male rats were used and divided into five groups as follows: normals, thyroidectomized without the drug, and thyroidectomized with 10 mg., 20 mg., and 30 mg. administration of the drug. During the period of injection the thyroidectomized rats receiving 10 mg. per kilogram per day of dinitrophenol showed a decrease in activity of 23 per cent below the post-operative period and 66 per cent below the pre-operative state. The rats receiving 20 mg. demonstrated a fall in the activity level of 18 per cent of the post-operative condition and 78 per cent pre-operative. The rats injected daily with 30 mg. per kilogram of body weight per day fell below the post-operative state by 23 per cent and pre-operative by 65 per cent in activity. In every case dinitrophenol failed to raise the bodily activity of the thyroidectomized rats to the post-operative or pre-operative levels. Injections of dinitrophenol actually acted as a deterrent. The experiment suggests that there is no direct relationship between activity and the basal metabolism rate and that the thyroid hormone aids in sustaining normal activity independently of its influence on the basal metabolism of the rats. Hall and Lindsay state that this situation would explain in part the observations made by Peters and Van Slyke[18] why hyperthyroid patients with basal metabolism rates of 20–30 per cent below the norm can often make complete recovery on small doses of thyroid without significant increases in basal rate.

THE PITUITARY

Hatai[6] in his study of the wild Norway rat noted that the weight of the male rat of this breed was 11 per cent less than that of the albino and that of the Norway female rat less than that of the albino by 46 per cent. In his study on the influence of exercise on the organs of the albino rat[7] he found that the hypophysis responded to exercise differently in each sex. He observed an increase in weight of 10.25 per cent in the male and a reduction of 22.23 per cent in the female.

There seems to be a suggested interrelation here between the weight loss witnessed by him in the albino male rat and the difference in the weight of the hypophysis of the domesticated and the wild Norway rat.

Richter and Wislocki[19] in 1930 demonstrated that hypophysectomy produced an abrupt decrease in activity of rats and also showed a decrease in food intake and body weight.

Richter and Eckert [20] verified Richter and Wislocki's work in 1937 by also finding a reduction of activity in hypophysectomized rats. A typical record of the hypophysectomized rat in their experiment showed a decrease of activity from an average level of 11,900 revolutions per day for a 10-day period before operation to an actual level of 1,227 revolutions per day 10–20 days after hypophysectomy. The food intake dropped from 14.1 grams to 7.5 grams during the same period and body weight from 160 to 130 grams.

In this same experiment on hypophysectomized rats, the investigators observed also that the effect produced by daily injections and the effects produced by hypophysial implants to the anterior chamber of the eye had a pronounced influence on the reduced activity level of the hypophysectomized rats. Injections of fresh anterior lobe extract produced a reduction in activity in the males and females with an accompanying loss of weight in the male of small consequence and a fair gain in the female. There was a reduction of food intake in both sexes and replacement therapy carried conditions to a higher level than in the case of the untreated rats. The failure of injections to maintain normal growth and activity may have been due to daily injury and to the discomfort of the daily injections, or to the failure of the injection to maintain the normal function of other endocrine glands such as the adrenals.

The effects produced in the reproductive tract were quite divergent. Four of the experimental animals showed cornification of cells; two showed irregular periods of prolonged cornification; and one showed complete absence of cornification in the vaginal smear. In animals raised from one to two glands per day the vaginal smears changed from continuous cornification to epithelial cells and leucocytes. (The glands used were secured from 12-day-old rats.)

In regard to hypophysectomized rats treated with pituitary implants none demonstrated full maintenance of activity. Activity after operation was approximately 5,000 revolutions per day which is considerable above the activity level reached by the untreated rats. The body weight of the rats with implants increased to slight degree but the food intake showed a decrease. The vaginal smears presented a continuous diestrus picture. In comparison to pituitary injections of the anterior lobe extract, the implants had a relatively greater effect on activity than on food intake, body weight, or reproductive tract.

The comparative glandular weights of the endocrines of the normal,

treated, and untreated rats are presented in Table I. A review of this table shows that the anterior lobe injections have the greatest effect on the ovaries and the next greatest on the thyroid. The adrenals and pancreas are least affected. It may be that the failure to secure full activity with anterior lobe extract injections was due to the failure of the pancreas and adrenals to function adequately. Richter [21] demonstrated in 1936 that both activity and food intake are markedly affected by the adrenals and less so by the pancreas. This situation may indicate that Richter and Eckert's failure to obtain full activity was directly due to the lack of adrenotropic hormone.

TABLE I

COMPARATIVE GLANDULAR WEIGHTS IN MILLIGRAMS

Group	No. of rats	Age at Operation	Age at Autopsy—Days	Thyroid	Ovaries	Uterus	Adrenals	Pancreas	Thymus
Normal females	6	...	100	19.0	68	377	33	977	576
Hypophysectomy injections—two anterior lobes per day	3	84	107	20.5	225	402	32	896	148
Hypophysectomy injections—one anterior lobe per day	4	90	137	21.0	82	342	27	...	273
Hypophysectomy with whole hypophysis implant	16	67	103	14.0	33	101	19	485	237
Hypophysectomized rats untreated	7	65	93	12.4	32	126	12	485	122

It is of interest to note that in Richter and Eckert's study the food intake of the hypophysectomized rats treated with anterior lobe injections did not remain on a higher level but indicated regular cyclic fluctuations. The food intake variations were from 3 to 16 grams per day and recurred at intervals of 6–11 days. These fluctuations of food intake are of significance since Richter[22] showed cyclic fluctuations in food intake on the section of the pituitary stalk. The cycles he witnessed in this case also affected activity of the rats who showed sudden bursts of activity at regular intervals with relatively low plateaus in between. This phenomenon appeared only in the experimental females. The vaginal smears demonstrated cornified cells on the days of high activity and diestrus smears on intervening days. Ovariectomy subsequently eliminated all cycles in activity and food in-take. The cycles observed by Richter on section of the pituitary stalk have their origin

in the pituitary. The function of the ovaries and testes is dependent on the secretion of the pituitary since without its secretion these glands become inactive or atrophy. As an indication of its influence Smith and Engle[23] produced ovulation in rabbits by anterior lobe implants.

The removal of the anterior lobe of the pituitary in the rat causes extensive atrophy of the adrenal cortex and also decreases the capacity of the skeletal muscles to sustain work when faradic stimulation is applied. Ingle, Moon, and Evans,[24] primarily to investigate the effect of the adrenocorticotropic principle isolated by Moon and secondarily to study the effect of mammotropic, growth, and thyrotropic principles on hypophysectomized rats, obtained the following results which will be briefly discussed here.

The work performance of the untreated hypophysectomized rats as measured against the controls in faradic stimulation of the gastrocnemius muscle working against a load of 100 grams was greatly decreased below the normal and the work totals were small.

Hypophysectomized rats treated daily with the growth principle did not lose body weight and the total work values were definitely higher than the untreated animals. Atrophy of the adrenals was not so marked as in the case of the untreated rats. The results were very similar to those obtained when the rat was treated with the mammotropic and thyrotropic principles.

On daily treatment with 2 mg. of adrenocorticotropic principle the values of the initial rate of work approach normal. The weights of the adrenal glands were all within the limits of normal variability and the average value compared favorably with the normal adrenal weights of the control rats.

In an additional experiment these investigators removed the pituitary and adrenal glands from twenty rats in a single stage operation. Ten rats were given 2 mg. of adrenocorticotropic principle daily and the remainder received no therapy. The 10 experimentals repeated the same results as in the experiments with the adrenals intact.

The experiment indicates that the adrenal secretion (cortin) has a definite effect in increasing work performance in hypophysectomized rats and that the adrenocorticotropic principle has a similar effect when the adrenals are present but no additional effect on work performance when they are absent.

Ingle[25] in 1936 showed that when adrenalectomized rats are maintained on large doses of cortin, the animals reached a normal capacity for work. Since hypophysectomy causes atrophy of the adrenals, Ingle[26] in 1938 performed an experiment on hypophysectomized rats with subsequent cortin therapy. In many cases the animals receiving treatment with cortin showed a greater work performance than did the untreated ones. Ingle observed that the administration of cortin did not influence the extent of atrophy of the ardenals. He further stated

that the work performance of the hypophysectomized rats treated with cortin was still very small when compared to normal animals and also that he has never been able to confirm the claims of some investigators that cortin administration in normal animals increased work performance.

THE ADRENALS

Hatai[6] found the adrenals of the male Norway rat heavier than that of the albino by 7 per cent and the female of the same species outweighed the adrenal of the albino by 80 per cent. The glands in both sexes of the Norway rats were ashy white while those of the albino were deep olive in color.

In Hatai's[7] experiment on the effect of exercise on the growth of organs in the albino rat, he noted practically no change in the male adrenal weight between the experimentals and the controls (0.84 per cent) while there was an increase in the weight 47.76 per cent in the female.

In the study made by Steinhaus[8] on dogs the runners showed a 21 per cent increase in weight and the swimmers a 28 per cent increase in adrenal weight.

Knouff and his co-workers (unpublished) made a study of the lipid content of the adrenal cortex of rats that ran on a treadmill to exhaustion. They disclosed by chemical analysis that there was an increase of lipid content in the inner fascicular zone and a slight increase in the glomerulosa and recticulata. On using three-hour exercise periods, the adrenals showed atrophy and the lipid content increased with the hypertrophy. Additional variations were noted in regard to the effect of exercise which they summarized as follows:

Analysis of Variation

Factors affecting adrenal weight:

1. Effect of exercise: Exercise caused hypertrophy of each treated adrenal gland.
2. Effect of sex: The males have larger adrenals on both sides.
3. Effect of side: The left adrenal gland is significantly heavier than the right.
4. Effect of pairs: There is a highly significant correlation between adrenal weights and body weights.

Interaction:

1. Effect of exercise and sex: Both sexes respond to a significant degree to exercise.
2. Effect of exercise and side: Both right and left adrenals were affected by exercise.
3. Effect of pairs: Each pair gave a significant response to exercise.
4. Effect of sex and sides: The response to exercise was significantly different in the two glands. Of the right and left in the female the right adrenal gland showed the greatest hypertrophy. In the male both glands were equally affected by exercise.

Durrant [27] in 1924 investigated the effect of adrenalectomy on the activity of the rat. He found a marked diminution in the voluntary activity of 24 experimentals over a period of 7 weeks. By extending the experimental period for 16 weeks he observed that 7 of the rats completely recovered in 35 days, 10 showed partial recovery, and the remaining 7 showed marked adynamia throughout the entire period.

Gans and Miley[28] attacked the same problem in 1927 by the use of the ergographic tests (stimulation of the gastrocnemius with faradic current) in which they employed 21 experimentals and 18 controls. They observed that the total work performance by the adrenalectomized rats was $\frac{1}{16}$ of that done by the controls in terms of complete fatigue. Hales, Haselrud, and Ingle [29] verified their work in 1935. The initial height of contraction of the gastrocnemius muscle of the experimentals and the controls compared favorably but the experimentals from this point showed a rapid reduction in the height of contraction and complete fatigue within 6–10 minutes while the controls sustained the initial height of contraction for several hours and complete fatigue set in variably from 8–26 hours.

Richter[30] studied the activity of adrenalectomized rats when treated with adrenal implants, fed on cortical extract, given excessive doses of salt, injected with epinephrine and growth hormone, and untreated. Richter found the activity curve of the untreated adrenalectomized rats of two types: those which showed a drop from the normal activity level of 10,000 revolutions per day to a level of 400, and those that dropped to a level of 600 revolutions per day. In both cases the food in-take and body weight were markedly reduced.

Whole adrenal implants placed in the ovaries at the time of adrenalectomy caused a decreased activity curve although less marked than that of the untreated experimentals. The ovary with the adrenal implant was removed in 30 days in all animals showing an increase in activity level above the level of the untreated rats. A decrease in activity and the appearance of other symptoms was regarded as proof that the graft had taken. Although activity was decreased at first on implantation and adrenalectomy, there was a gradual increase in the activity level until it finally reached the post-operative state which was, on the average, 20 days later.

Ingle and Harris[31] in their investigation of adrenal implants in the ovaries of rats and its effect on activity, substantiated the results of Richter when they observed the experimentals' activity at a normal level. Since they were making a study of the dispute of whether or not activity is dependent on the cortex or the medulla and inasmuch as they found only cortical tissue in the grafts, Ingle and Harris suggested activity is dependent on the secretion of the cortex of the adrenals.

Four of the 17 animals maintained on the feeding of cortical extract

showed a definite increase in activity while the remainder were unaffected.

The 26 rats maintained on McCollum's salt diet became totally inactive and died, or showed a persistent low running curve. The animals maintained on a 1 per cent salt solution plus McCollum's diet demonstrated a slight but definite increase in activity, body weight, and food consumption. Three of 5 rats were maintained on a 3 per cent salt solution and these showed an even greater increase activity. Richter suggested that even greater increases in activity might be attained by larger administrations of salt or by a mixture of salt other than sodium chloride.

The daily injection of 1 cc. of the growth hormone produced no effect on activity, body weight, or food in-take.

Richter found, even as Nice, Greenberg, and Greenberg,[32] that daily injections of 0.05 cc. of epinephrine had no effect on the activity of adrenalectomized rats. Epinephrine sulphate given in the food produced no change in bodily activity. Both epinephrine and epinephrine sulphate with increased dosages of salt were also given without any particular consequences.

Richter's experiment demonstrates clearly the great dependence of activity upon the secretion of the adrenal gland and, as suggested by Ingle and Harris as well as Richter, the source of this influence is located in the cortex of the adrenals. The presence of cortical tissue only in the ovarian implants on autopsy and the ineffectiveness of epinephrine to raise the activity level gives the cortex specificity.

Since the cortex was considered involved in the restoration of the activity level in adrenalectomized rats, and since muscular adynamia has long been known as a symptom of Addison's disease, many studies have been stimulated in the effectiveness of cortical extract in eliminating muscular fatigue.

As previously cited, Ingle stated that in all his experimentation he never observed an increase in the ability of normal rats to perform more work with cortical injections. Eagle, Britton, and Kline[33] reported in 1932 that they observed an increase in the capacity of trained dogs for long durations of work amounting to as much as 100 per cent on the administration of cortical extract. Tipton,[34] in a study of the effect of cortin on the electrolyte changes in cat muscle, demonstrated that in stimulations of 2½ hours the muscles showed a much greater loss of potassium with an approximate gain of sodium than do muscles stimulated for a period of 30 minutes. Water may actually pass out of the muscle during such stimulation. During recovery of the muscles the changes were reversed. Neither the changing of the concentration of potassium or calcium nor the injection of cortin had significant effect on the recovery of the muscles during stimulation as indicated in electrolytic analysis.

Ingle[35] in his investigation of the time for the occurrence of cortico-adrenal hypertrophy in rats during continued work, considered the role of cortin, hypophysectomy, and adrenotropic principle in regard to the weight of the adrenals when the rat was placed under stress. The constant state of stress was secured through anaesthesia, muscular work, and starvation. Eighty rats were worked and 10 rats killed at the end of 6, 24, 48, 72, 96, and 120 hours after the gastrocnemius muscle had been stimulated to work against a 100-gram load for 12 hours at the rate of 3 stimulations per second. A small but unreliable increase was noted in the weight of the adrenals after 6 hours stimulation. There was a direct proportion between the increase in the weight of the adrenals and the number of hours from this point. Ingle assumed that the increase in weight was due to the increase in the requirement of cortin and that this response is facilitated by the adrenotropic principle of the pituitary. Hypertrophy did not occur during the work when similar rats were either hypophysectomized or treated with cortin. The administration of adrenotropic hormone to hypophysectomized rats produced hypertrophy of the adrenals in 12 hours. Ingle referred to Selye's functional adaptation which occurs rapidly in the adrenal cortex and which is mediated by the adrenotropic principle of the pituitary.

Hitchcock, Grubbs, and Hartman[36] in 1938 studied the effect of adrenal cortical extract upon the oxygen consumption in normal human beings. Exercise consisted of walking on a treadmill at the rate of 100 meters per minute, or in simply standing erect. In the main their study showed that the extracts had no significant effect on the basal oxygen consumption. The oxygen consumption was reduced 6 per cent in 9 of the 12 subjects on standing erect. In walking on the treadmill there was an even greater reduction in oxygen consumption and this reduction occurred in 10 of 12 subjects amounting to an average of 10 per cent. These investigators, however, do not credit the reduction of oxygen consumption to cortical extract but rather to some factor contained therein.

Missiuro, Dill, and Edwards,[37] in their study of the effect of adrenal cortical extract in rest and work on normal subjects during walking at the rate of 5.6 km. per hour on an 8.6 grade, found that the oxygen consumption was about 1.5 liters per minute. In walking with no grade the oxygen requirement was raised 4 times the basal value. The most strenuous work, which consisted of running at the rate of 11.2 km. per hour for 4–5 minutes, was not made easier by cortin administration. In most of the experiments, however, the administration of cortin decreased oxygen intake in the last minutes of work but there was no greater capacity for oxygen intake or for anaerobic work.

These investigators found no change in the number of red cells during rest or work, but they did disclose a rise in the number of white

cells in two subjects (6,500–7,150 and 6,600–9,650) and neutrophiles (2600–3,700 and 3,830–4,730) after cortin administration. A lower level of blood pressure appeared to be a characteristic effect of cortin injection after completion of work and the time required for the return of the blood pressure to normal was shorter.

Inodvina[38] has suggested that cortin caused a more economical use of carbohydrate reserves, or an increased efficiency of the metabolism of carbohydrate in muscles. Missiuro, Dill, and Edwards found no correspondence between oxygen consumption in their experiments and the proportion of energy derived from carbohydrates as revealed in the measurement of the R. Q.

Britton, Silvette, and Kline[39] in a study of the carbohydrate and electrolyte changes in adrenal insufficiency in dogs noted a pronounced carbohydrate lack in adrenal insufficiency. In over 50 experiments with adrenalectomized dogs, the average blood sugar levels were reduced 40 per cent. Liver glycogen was 85 per cent below normal and in many cases approached the state of exhaustion. Heart glycogen was reduced 75 per cent and muscle glycogen 45 per cent. In the case of short survival as compared with long survival, the blood sugar fell to about the same level.

Cortico-adrenal extract restored normal blood sugar level and markedly reduced high blood urea in a space of 12–24 hours. Simultaneously there were only significant changes in the blood serum sodium and chloride levels. On injection of large amounts of sodium chloride in the adrenalectomized dogs, the levels of the blood serum sodium and sodium chloride rose to normal but the blood sugar level fell. Injections of adrenalin did not raise the blood sugar level significantly.

The evidence presented suggests that the adrenals may secrete two substances, one of which keeps the animal alive while the other keeps him normally active. At least experiments indicate that activity is dependent largely on adrenal secretion whatever the specific principle may be. Adrenalectomy of animals shows an immediate reduction in activity, which again reaches a normal level on the administration of cortin, adrenotropic principle, or implants. There is no evidence to settle definitely whether or not the mechanism of the effect of cortin is related to some change in the circulation, metabolism, nervous regulation, or, as has been suggested by Hartman, to local changes in muscles.

THE GONADS

Hatai[6] found the sex glands of the wild Norway rat heavier than the domesticated albino. The testes of the Norway rat were 21 per cent heavier and the ovaries 26 per cent heavier than the albino rat. Albino rats that were exercised in the revolving cage[7] showed in the male experimentals an increase of 12.33 per cent in weight over the controls. The ovaries of the exercised rats had an average increase in

weight of 84.33 per cent over the controls. Hatai suggested that the increase in weight in the case of the female exercised rat indicated a return to the wild form not in size alone but also in fertility.

In Steinhaus' work with dogs, the runners showed a reduction of 9 per cent and the swimmers a 38 per cent decrease in weight of the testes. These observations are in contradiction to Hatai's results. Steinhaus pointed out in his discussion that in running and swimming, the kidney, spleen, and the adrenals seem to be affected differently and are particularly sensitive to conditions of asphyxia which is produced by the increase in carbon dioxide tension and blood pressure. (Rice and Steinhaus. [40])

Hoskins[41] observed that castration of male rats produced a decrease of about 60 per cent in activity. Wang[42] also noted that after ovariectomy the activity of the female rat was decreased 90–95 per cent and that the cyclic rhythm of activity dependent on the estrus cycle was abolished. Durrant [43] in 1924 confirmed Wang's results. Gans and Hoskins,[44] employing ergographic tests, showed that of normal and castrate males the total work performance was considerably less in the castrate. These investigators found that the individual weight of the gastrocnemius muscle was greater in the case of the castrates than in the controls but the strength gram per gram of muscle averaged nearly the same in all groups.

Miley[45] in 1927 checked the work of Wang and Durrant using essentially the same technique and employing the ergographic test of Gans and Hoskins with slight modifications in a study of the fatigability of muscles in castrate male and female rats. The average daily activity 10 days prior to ovariectomy was 9,885 revolutions and 11,397 respectively for experimentals and controls. After a period of 20 days after ovariectomy the experimentals performed on the average 1,883 revolutions per day (82 per cent decrease) and the controls 9,898. The activity of the ovariectomized rats dropped to a low level in periods ranging from 11–35 days with an average of 20 days which agreed with the results obtained by Durrant[46] in 4 of his ovariectomized rats. There is evidently a direct relationship between the continuous effectiveness of the ovarian hormone and activity.

Miley observed in his ergographic tests that the female rats maintained a greater level in activity than did the males. Hitchcock[47] reported in his experiment in 1925 that the activity of the males was 56 per cent of that of the females on castration. Wang, Richter, and Guttmacher[48] in the same year reported that the average daily activity of the males on castration fluctuated between 2,000–8,000 revolutions while the female varied between 6,000–12,000. Richter[49] found that gonadectomized males and females were equally active at every age. Miley observed that gram per gram the gonadectomized female rat

could do more work than the males. In the females there was an average increase of 23 per cent in the work performance in the experimentals as compared with the controls. The gram per gram comparison of muscle strength showed a decrease of 40 per cent for the experimentals. There was no gram per gram difference in the experimental and control males.

Wang, Richter, and Guttmacher, Richter,[50] and Richter and Wislocki[51] showed that rats spayed or castrated before puberty (28–40 days) maintain a constant level of activity throughout life which averages less than 2,000 revolutions per day in the female. Implantations of ovaries in the pubertal spayed or castrated rat caused an increase of 1,000 revolutions above the normal of 10,000. Bugbee and Simond[52] observed that injections of follicular extracts into the spayed rat raised activity to the normal level while in the male, implanted testes in the pubertal castrate produced a less marked but similar effect.

The factors involved in the maintenance of the level of activity after gonadectomy are not clear. Some investigators suggest that other glands are involved, such as the pituitary and adrenals. It is possible that these two glands individually or collectively are responsible for the return of higher activity levels in gonadectomized rats.

Aside from the studies made on the effect of gonadectomy and its effect on activity, several studies have been made on the effect of hysterectomy in the same relation. Investigations by Loeb[53] have shown that hysterectomy in guinea pigs prolonged the life and function of the corpus luteum on removal of all or part of the uterus, with the indirect effect of preventing ovulation as long as the corpus luteum existed. Hartman[54] on the other hand showed that hysterectomy had no effect on the estrus cycle of the opossum. Long and Evans[55] made the same observation in regard to white rats.

Durrant[56] in 1927 made a study on the effect of hysterectomy on the activity of the rat. Twelve rats were typed by the vaginal smear method and daily observations were made until the length of the estrus cycle could be determined. The uteri of these were removed. A second series of 14 animals were observed, typed, hysterectomized, and placed in the activity cages. In the first series there was a disappearance of the cyclic vaginal changes within 3–4 days after operation. In an average time of 23 days, the estrus cycle was completely restored.

In the second series hysterectomy caused an immediate fall in activity followed by a larger increase in the next cycle and a complete recovery at the succeeding cycle. Durrant's experiment in regard to the recovery of activity after the elapse of two cycles indicates that hysterectomy has only a temporary effect on the estrus cycle which does not interfere with the hormonal function of the ovaries and which is probably due to operative shock.

THE PANCREAS

A survey of the literature in the field shows no report on the changes of organ weight of the pancreas as a result of exercise but there are many citations which consider the role of exercise in insulin therapy in diabetics. Lawrence[57] reported several case studies in the *British Medical Journal* which considered the effect of exercise on insulin action in diabetics. In one particular case history the patient while leading an inactive life required 16 units of insulin per day to maintain the normal blood sugar level. On return to active life, which consisted of routine office work and playing cricket, he immediately experienced the unpleasant symptoms of hypoglycemia each day before his noon-day meal. The injections of insulin were accordingly reduced to 6 units per day with satisfactory maintenance. After cessation of work once again sugar appeared in his urine and the insulin requirement was raised.

Lawrence conducted an experiment on diabetic patients which he classified into two groups, one of which received insulin and no exercise and the other insulin plus exercise. The general results of this controlled experiment verified his observations on his routine patients, namely that muscular activity greatly enhanced the action of insulin. Gerl and Hofmann[58] made the same observation and suggested that exercise stimulates the remaining islets to greater activity. Staub[59] and Depisch and Hasenöhrl in support of this thesis have reported that in the muscular work of dogs there was an increase in the production of insulin.

It has been suggested that with training the pancreas of the normal man responds with insulin more promptly, so that the initial hyperglycemia of exercise ceases to appear. Gerl and Hofmann suggested in their discussion that sugar cannot be taken up by the cells without insulin and that accordingly in muscular work more insulin is produced. In diabetic patients this recruitment is accomplished through the stimulation of the remaining islet tissue.

THE PARATHYROID AND THYMUS

The following notations concern the parathyroid and the thymus in relation to activity. There is little literature available which concerns these endocrine glands and their role as it relates to actual measurement in activity. To be sure, much is known concerning the role of the parathyroids and the effect of hypo- and hyper-secretion on the musculature in pathological conditions.

Durrant,[60] in a news item in the *American Journal of Physiology*, gave a short discussion on the effect of parathyroidectomy on the activity of the rat. Using the revolving cage method and unilateral and bilateral parathyroidectomy he observed in rats 90–100 days old that though tetany was equally pronounced after both types of operation,

the activity was merely temporarily depressed. He stated recovery of activity was more rapid in the unilateral parathyroidectomy.

Hatai[7] after exercising rats from 90–180 days found an average increase in the weight of the thymus of the exercised rat of 4.8 per cent over the control, but he concluded by saying that the variations were so great nothing definite could be concluded as to whether or not exercise affected the weight of the thymus.

SUMMARY AND CONCLUSIONS

1. Thyroidectomy, when complete and no accessory tissue is present, causes a decided drop in the activity level in rats. Therapy will restore the activity level to near normal. On thyroidectomy wide fluctuations and cyclic changes appear in activity. Richter has suggested that these cyclic changes may be due to the pituitary, adrenal, or gonadic glands.

2. Hypophysectomy produces an abrupt decrease in activity. On therapy, anterior lobe extracts encourage a greater return to the normal level than any other form. Hypophysectomy causes an atrophy of the adrenal cortex and a diminution in the capacity of skeletal muscles to sustain work. Cortin has a definite effect on the increased work performance of hypophysectomized rats and adrenotropic principle has the same effect whether or not the adrenal glands are present.

3. In the comparison between the exercised experimentals and the quiescent controls, the adrenals show a gain in weight in both sexes with the greatest increase in favor of the female. On exercise the adrenal cortex, especially the fascicular zone, shows an increase in lipid content. There is a marked diminution in activity on adrenalectomy. Adrenalectomized rats show the greatest recovery to the normal activity level when treated with cortical extracts or adrenotropic principle but epinephrine of the medulla produces little improvement in the activity level. Indications are that the adrenal cortex is responsible for the return of the activity level toward normal since adrenal implants in the ovaries in the adrenalectomized rat after a return to a higher activity level show, on autopsy, active cortical tissue in the ovary. Cortin seems to decrease the oxygen requirement of active normal human subjects although experimental studies on the ability of cortin to aid the recovery of fatigued muscles as evaluated in electrolytic changes after administration does not verify this increase in efficiency of bodily processes. Studies of carbohydrate and electrolyte changes in adrenal insufficiency indicate that there is a general reduction of sugar in the blood and glycogen in the muscles and liver. Cortical extract restores the normal blood sugar level but serum sodium and sodium chloride show no changes. Administration of large amounts of sodium chloride restores blood serum sodium chloride level but has no influence on the blood sugar level. There is no evidence to settle

definitely whether or not the mechanism of the effect of cortin is related to some change in circulation, metabolism, nervous regulation, or, as has been suggested by Hartman, to local changes in the muscles.

4. There is a large increase in the weight of gonadic tissue as a result of exercise in both the male and female. On gonadectomy there is a reduction in activity but the female is capable of greater work performance than the male. Therapy on gonadectomy seems to have more effect in the restoration of the activity level toward normal in the case of the female than in the male. The pituitary and the adrenals probably assist in the restoration of the activity level in the gonadectomized rat. Hysterectomy has an immediate effect on the activity of the female rat but this is only a transitory one, owing primarily to operative shock since the estrus cycle and the activity level return to normal in a very short time.

5. There are no available studies on the effect of exercise on the weight of the pancreas. Investigations, however, of exercise and insulin therapy indicate that the effect of insulin is enhanced when accompanied by muscular activity. It is suggested that body cells cannot take up sugar without insulin and that accordingly in muscular work more insulin is produced. In the diabetic this demand is met by the stimulation of the remaining islet tissues.

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Skeletal Symmetry and High Jumping

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"ARE there any peculiarities of stature prevalent in the athlete that are not found in the non-athlete?" An attempt was made by the writer, in answer to this problem, to determine the skeletal peculiarities of expert high jumpers as compared with non-expert jumpers.

The items that were measured were obtained as a result of the consensus of the outstanding track coaches of the country. The skeletal measurements that were taken were those of weight, height, length of legs, breadth of foot, and girth of hips.

SUBJECTS

A group of 561 college men who had never received any specific training in the running high jump, as members of high school or college track teams, were compared with 16 men who had had specific training in the running high jump as members of college track teams.

The non-expert group will be referred to as the *non-track group*, and the expert group as the *track group*. The track group consisted of high jumpers throughout the country who had attained the height of six feet or over in the running high jump.

PROCEDURE FOR MEASURING

A detailed description, covering the securing of the measurements, is contained in a previous study in the Research Quarterly.[1]

TECHNIQUE OF THE INVESTIGATION

The first step in the procedure was to determine the relationship of each of the skeletal measures of the non-track group to ability in the running high jump.

The skeletal, or physical, measures were then considered in various combinations. From the data of the non-track group, that combination of measures was secured which had the maximum relationship with high jump ability with a minimum number of measurements. The combination of skeletal measures selected to predict the expected height to which an individual will jump, included these: height, length of legs, and breadth of foot. These measures have the greatest zero-order relationship with high-jumping.

[1] H. Krakower, "Skeletal Characteristics of the High Jumper," Res. Quart., 6:2 (May 1935) 75.

The multiple correlations of combinations of variables in relation to high jump ability for the freshman-sophomore (non-track) group are shown in Table I and that of the junior-senior group in Table II.

TABLE I

MULTIPLE CORRELATIONS OF COMBINATIONS OF VARIABLES IN RELATION TO HIGH JUMP ABILITY FOR THE FRESHMAN-SOPHOMORE (NON-TRACK) GROUP

Variables	Multiple Correlations
Weight—Hips	.0469
Weight—Foot	.0616
Foot—Hips	.0663
Weight—Foot—Hips	.0707
Height—Foot	.2100
Height—Hips	.2257
Height—Foot—Hips	.2257
Weight—Height	.2312
Weight—Height—Hips	.2316
Weight—Height—Foot	.2321
Weight—Height—Foot—Hips	.2321
Leg—Foot	.2506
Height—Leg	.2548
Height—Leg—Foot	.2560
Leg—Hips	.2634
Leg—Foot—Hips	.2634
Weight—Leg	.2648
Weight—Leg—Foot	.2655
Weight—Leg—Hips	.2663
Weight—Leg—Foot—Hips	.2663
Height—Leg—Hips	.2713
Height—Leg—Foot—Hips	.2716
Weight—Height—Leg	.2776
Weight—Height—Leg—Foot	.2776
Weight—Height—Leg—Hips	.2780
Weight—Height—Leg—Foot—Hips	.2780

The members of the non-track group who jumped highest were compared with those in the lowest percentile, to see if the combination of measures selected was prominent in the men who jumped best. The results substantiated the selection. The members of the non-track group who jumped highest were taller and had longer legs and broader feet than those in the lowest percentile. The poorer jumpers, on the other hand, were heavier and had a larger hip measurement.

Regression equations were then formulated to determine the expectation of skeletal symmetry. The material below explains the procedure followed to determine skeletal symmetry.

SKELETAL SYMMETRY

The non-track men were compared with the expert jumpers to see if the two groups were different skeletally. The steps in the procedure follow:

TABLE II

MULTIPLE CORRELATIONS OF COMBINATIONS OF VARIABLES IN RELATION TO HIGH JUMP ABILITY FOR THE JUNIOR-SENIOR (NON-TRACK) GROUP

Variables	Multiple Correlations
Weight—Hips	.1278
Foot—Hips	.1889
Height—Hips	.1945
Height—Foot	.2283
Weight—Foot	.2308
Height—Foot—Hips	.2415
Weight—Foot—Hips	.2502
Weight—Height	.2666
Weight—Height—Hips	.2810
Weight—Height—Foot	.3110
Weight—Height—Foot—Hips	.3317
Leg—Hips	.3748
Height—Leg	.3961
Leg—Foot	.3973
Height—Leg—Hips	.3973
Weight—Leg	.4007
Leg—Foot—Hips	.4030
Weight—Leg—Hips	.4066
Weight—Height—Leg	.4082
Weight—Height—Leg—Hips	.4131
Weight—Leg—Foot	.4311
Height—Leg—Foot	.4378
Height—Leg—Foot—Hips	.4382
Weight—Leg—Foot—Hips	.4479
Weight—Height—Leg—Foot	.4499
Weight—Height—Leg—Foot—Hips	.4593

Comparison of the means of the non-track group with the skeletal measures of members of the track group.

Comparison of the residuals of members of the non-track group who are like the track men in their gross measurements, with the residuals of the track men.

The skeletal symmetries to be expected in a normal sampling of the non-track group may be determined from regression equations formulated from the skeletal traits of height, length of leg, and breadth of foot. These measures have the greatest relationship to ability in the running high jump.

A. *Expectation of Skeletal Symmetries of the Non-Track Group.*—In formulating equations for the prediction of skeletal symmetries, each of the measures was used as a criterion for prediction, and regression equations [2] were formulated.

B. *Skeletal Symmetries of the Track Group.*—The skeletal measurements for height, length of leg, and breadth of foot of the track group

[2] *Ibid.*, p. 84.

were compared with those for the non-track group. The skeletal regression equations were applied to the track group to determine the symmetries of its members.

1. Comparison of the Means of the Non-Track Group with the Skeletal Measures of the Track Group.

In comparing the dimensions of each individual of the track group with the means of the non-track group, the following results were obtained: [3]

	Track Group	*Freshman-Sophomore Group*	*Junior-Senior Group*
Height	Greater	170.9316 cm.	170.5740 cm.
Length of Leg	Greater	81.6174 cm.	80.7180 cm.
Breadth of Foot	Greater (except in two cases which reach 95.0 mm.)	95.1014 mm.	94.3820 mm.

2. Application of the Skeletal Regression Equations to the Skeletal Measures of the Track Group.

To determine the skeletal symmetries of the track group, the skeletal expectation or prediction formulas, were applied. Table III is a tabulation of the results. It includes:

a) Actual measure for each of the three skeletal characteristics.

b) Expectation of each of the three characteristics, derived from the other two.

c) Actual measure minus expectation, which is the residual or the amount of divergence from normal symmetry.

d) The residual divided by the standard deviation of the residuals of that kind, giving a standard score.

e) Approximate per cent of individuals likely to be as atypical or more atypical. For example, for an individual with a standard score of symmetry of 2.5, the approximate per cent of individuals more unusual will be 1.24. The per cent is based on a normal probability curve of 10,000 cases. [4] Or, in terms of individuals, in a normal distribution of 10,000 cases, 124 of them will be more unusual. The greater the number of individuals who are more unusual than a given case, the more symmetrical is the case.

(1) Residuals or Deviations of Actual Skeletal Measures from Expectation:—Track Group.

By applying the skeletal regression equations to the data of the track group the expected skeletal measure resulting from the other two measures may be determined. The expected measure is the kind of symmetry expected in a normal sampling. The difference or deviation be-

[3] See also *ibid.*

[4] Henry E. Garrett, *Statistics in Psychology and Education*, p. 91.

TABLE III

Symmetries of Physical Stature—Track Group

Case No.	(Cm.) Height					Leg Length (Cm.)					Breadth of Foot (Mm.)				
	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual
1	182.9	189.4861	—6.5816	—1.3715	17.06	99.10	86.9831	+12.1169	+3.8782	0.01	99.0	100.7738	—1.7738	—0.3056	75.66
2	188.6	193.8210	—5.2210	—1.0879	27.58	102.85	89.5908	+13.2592	+4.2438	0.01	102.0	102.7527	—0.7527	—0.1297	89.66
3	190.5	190.5680	—0.0680	—0.0142	99.20	99.15	90.3788	+8.7717	+2.8075	0.50	102.0	102.6307	—0.6307	—0.1087	91.24
4	186.7	188.4335	—1.7335	—0.4494	65.28	95.35	88.5346	+6.8514	+2.6846	0.74	104.0	99.7169	+4.2831	+0.7534	45.32
5	186.7	197.0359	—10.3359	—2.6796	0.74	103.30	88.5456	+14.7544	+5.7813	0.00	102.0	99.7145	+2.2855	+0.4020	68.92
6	186.7	192.2182	—5.5182	—1.4307	15.38	99.00	88.5456	+10.4544	+4.0964	0.01	102.0	99.7158	+2.2842	+0.4018	68.92
7	192.4	196.7402	—4.3402	—1.1252	25.84	102.90	91.3217	+11.5783	+4.5368	0.00	103.0	101.6018	+1.3982	+0.2459	80.26
8	189.2	198.8466	—9.6466	—2.5010	1.24	104.10	89.7326	+14.3674	+5.6296	0.00	108.0	100.5420	+7.4580	+1.3119	19.02
9	181.6	190.8102	—9.2012	—2.3879	1.68	96.52	86.0073	+10.5127	+4.1192	0.01	111.0	98.1279	+12.8721	+2.2641	2.38
10	189.2	195.5035	—6.3035	—1.6343	10.32	100.30	89.6996	+10.6004	+4.1536	0.01	114.0	100.5431	+13.6569	+2.4022	1.64
11	185.4	191.5996	—6.1996	—1.6073	11.96	99.40	87.9497	+11.4503	+4.4866	0.00	95.0	99.2852	—4.2852	—0.7538	45.32
12	181.6	189.9931	—8.3931	—2.1760	2.92	97.15	86.0623	+11.0877	+4.3445	0.01	101.0	98.0278	+2.9722	+0.5228	60.30
13	185.4	192.7760	—7.3760	—1.9123	5.74	100.45	87.9497	+12.5003	+4.8980	0.00	95.0	99.2849	—4.2848	—0.7537	45.32
14	188.0	192.2935	—4.2935	—1.1131	26.70	99.25	89.1910	+10.0590	+3.9415	0.01	100.0	100.1461	—0.1461	—0.0257	97.60
15	177.8	183.7032	—5.9032	—1.5305	12.60	91.40	84.2024	+7.1976	+2.8209	0.48	102.0	96.7713	+5.2287	+0.9197	37.76
16	177.8	184.4650	—6.6650	—1.7306	8.36	92.08	84.2024	+7.8776	+2.8516	0.44	102.0	96.7705	+5.2295	+0.9199	37.76

TABLE IV

Symmetries of Physical Stature—Non-Track Group*

Case No.	Height (Cm.)					Leg Length (Cm.)					Breadth of Foot (Mm.)					High Jump (Cm.)	
	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual	Actual Height Jumped	Deviation from Means
1	177.6	170.3223	+7.2778	+1.5165	12.86	85.45	84.5944	+0.8556	+0.2738	78.72	97.0	97.3290	—0.3290	—0.0567	95.22	143.73	+17.5782
2	177.0	169.3833	+7.6167	+1.5871	11.18	84.25	84.4718	—0.2218	—0.0710	94.42	100.0	96.9935	+3.0065	+0.5180	60.30	123.51	—2.6418
3	180.0	174.3666	+5.6334	+1.1739	24.20	89.40	85.6346	+3.7654	+1.2052	22.62	97.0	98.5366	—1.5366	—0.2647	79.48	143.73	+17.5782
4	178.0	169.7078	+8.2922	+1.7279	8.36	84.85	84.7678	+0.0822	+0.0263	97.60	97.0	97.3315	—0.3315	—0.0571	95.22	131.13	+4.9782
5	178.2	173.8819	+4.3181	+0.8998	36.82	82.40	85.3583	—2.9584	—0.9469	34.20	108.0	96.9934	+11.0066	+1.8964	5.74	131.13	+4.9782
6	181.0	174.6637	+6.3363	+1.3203	18.68	82.35	86.8008	—4.4508	—1.4245	15.56	113.0	97.6667	+15.3333	+2.6419	0.82	133.67	+7.5182
7	172.7	167.1993	+5.5007	+1.1462	25.02	82.40	82.4708	—0.0708	—0.0227	98.40	97.0	95.6542	+1.3458	+0.2319	81.80	131.13	+4.9782
8	178.8	175.3224	+3.4776	+0.8938	37.34	84.60	84.7179	—0.1179	—0.0462	96.02	97.0	97.1044	—0.1044	—0.0184	98.40	143.73	+15.4920
9	174.4	172.6985	+1.7015	+0.4411	66.00	81.85	82.5542	—0.7042	—0.2760	77.94	100.0	95.6483	+4.3517	+0.7655	44.12	115.89	—12.3480
10	173.5	174.0340	—0.5340	—0.1384	88.86	83.45	82.1315	+1.3185	+0.5166	60.30	97.0	95.3500	+1.6500	+0.2902	77.18	136.21	+7.9720
11	183.0	176.6266	+6.3734	+1.6524	8.90	85.90	86.7730	—0.8730	—0.3421	73.38	96.0	98.4946	—2.4946	—0.4388	66.00	126.05	—2.1880
12	175.0	179.1565	—4.1565	—1.0776	28.02	87.75	82.8525	+4.8975	+1.9190	5.48	99.0	95.8453	+3.1547	+0.5549	58.24	133.67	+5.4320
13	181.5	177.2048	+4.2952	+1.1042	27.14	85.60	86.0080	—0.4080	—0.1599	87.28	102.0	97.9981	+4.0019	+0.7039	48.40	138.65	+10.4120
14	174.4	180.9269	—6.5269	—1.6922	9.10	88.65	82.5322	+6.1178	+2.3972	1.64	104.0	95.6463	+8.3537	+1.4694	14.16	131.13	+2.8920
15	181.1	182.3430	—1.2430	—0.3223	74.90	90.05	85.8073	+4.2427	+1.6624	9.70	103.0	97.8643	+5.1357	+0.9034	36.82	151.35	+23.1120
16	176.5	173.4334	+3.0666	+0.7951	42.38	83.05	83.6010	—0.5510	—0.2159	83.58	96.0	96.3434	—0.3434	—0.0604	95.22	115.89	—12.3480

* Random selection of cases above the mean in height, leg length and breadth of foot.

tween the actual skeletal measure and the expected measure is known as a *residual*. It is the amount by which an individual differs in a given value from the dimension that he *ought* to have, where *ought* indicates the value which is common to individuals who are like him in other skeletal dimensions.

The actual and expected skeletal measures, as well as the residuals, are listed in Table III. The residual indicates if an individual is below or above expectation by expressing the amount by which an individual diverges from normal symmetry in each of the characteristics.

As noted in Table III, "all sixteen cases of the track group have minus residuals for height, indicating that every member of the group is shorter in height than would be expected from his length of legs and breadth of foot. Despite this fact, however, these individuals are taller than the average for the non-track group.

"The reverse is true of the residuals of leg length. In predicting the length of leg from height and breadth of foot, the residuals are all plus, as the actual skeletal measures are much greater than the expected measures. This indicates that every member of the group has legs extremely longer than would be expected from his height and breadth of foot.

"When the expectation of foot measure from height and length of legs was secured, it was found that six members of the track group had minus residuals, and the other ten had plus residuals. This indicates that there is no distinction possible as to the foot measure being above or below expectation, although they have broader feet than the average"[5] (probably owing to the fact that they are taller and heavier than the average).

From the above, it may be said that the expert jumpers are shorter in height than would be expected from their other skeletal measures. In length of leg, they are extremely above the expectation from their other skeletal measures. There is no distinction of expectation, as determined from their measures, for breadth of foot.

(2) Standard Score of Asymmetry of the Track Group.

The necessity of an interpretation of the degree of importance attached to the amount of a residual is emphasized in the comparison, for the same individual, of residuals of one kind with residuals of another kind. Being a given number of centimeters shorter than is warranted by the other skeletal dimensions must be compared with having legs a given number of centimeters less than is to be expected from the other skeletal dimensions. These amounts of asymmetry each need to be divided by some factor that renders these measures comparable, in order to obtain a standard score. That factor is the amount of dispersion in the particular dimension.[6]

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[5] H. Krakower, *op. cit.*, p. 82.
[6] Raymond Franzen, *Physical Measures of Growth and Nutrition*, pp. 59–60.

The standard score of asymmetry may be translated into the approximate per cent of individuals more unusual by interpolating the standard score of asymmetry in terms of the table, called by Garrett "Fractional parts of the total area (taken as 10,000) under the normal probability curve, corresponding to distances on the baseline between the mean and successive points laid off from the mean in units of standard deviation." [7] The greater the number of individuals more unusual than a given case, the more symmetrical is the case. [8]

For example (see Table I):

CASE NO. 1

Trait	Actual	Expected	Residual	Standard Score of Asymmetry	Approximate Per Cent More Unusual
Height	182.9	189.4861	—6.5816	—1.3715	17.06
Length of Legs	99.1	86.9831	—12.1169	—3.8782	0.01
Breadth of Foot	99.0	100.7738	—1.7738	—0.3056	75.66

The residuals in column four represent the degree to which this individual diverges from normal symmetry in each of the characteristics. Case 1 is smaller in height and breadth of foot and larger in length of leg than is usual for individuals having the other dimensions. However, column four is necessary to give the residuals practical value. Without this computation, one cannot estimate just how important it is to be 6.5816 cm. shorter or to have legs 12.1169 cm. longer, or to be 1.7738 mm. smaller in foot dimension than are others of the same height, leg length, or foot size. Otherwise stated, 6.5816 centimeters of divergence from expectation in height cannot be compared directly, in these absolute dimensional terms, with 12.1169 centimeters of divergence in leg length, or 1.7738 millimeters of divergence in breadth of foot. They can be made comparable, as the standard scores, by expressing them as multiples of their variation. The fifth column, in the illustration above, expresses the standard score of asymmetry. The sixth column expresses the significance of the standard score of asymmetry in terms of per cent. Thus, for Case No. 1, the standard score of asymmetry in height of 1.3715 means that 17.06 per cent of 10,000 individuals with the same leg length and breadth of foot, or 1,706 cases in a normal distribution of 10,000 will be more unusual.

The standard score of asymmetry and this approximate per cent of individuals, similar in other dimensions, who are more unusual are listed in Table III.

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[7] Garrett, *op. cit.*, p. 91.
[8] Franzen, *op. cit.*, p. 62.

In height expectation, the standard scores of asymmetry are all minus, indicating that every member of the group falls below the expectation from his length of leg and breadth of foot. The range is from 0.0142 to 2.6796, which is equivalent to 99.20 per cent, or 9920 cases in 10,000 for the former and 0.74 per cent, or 74 cases in 10,000 for the latter, of individuals who, having the same length of leg and breadth of foot, are more unusual in height.

In expectation of length of leg, the standard scores of asymmetry are all plus, indicating that every member of the group above has legs longer than might be expected from his height and breadth of foot.

The range is from 2.6846 to 5.7813, which is equivalent to 0.74 per cent (or 74 cases in 10,000) for the former and 0.00 per cent or 0 cases in 10,000 for the latter, of individuals of the same height and breadth of foot who are more unusual.

The standard scores of asymmetry for breadth of foot expectation are both plus and minus, indicating no general trend.

From the data presented above, the following characteristic symmetries may be noted for the members of the track group. "Their most significant peculiarity is the extreme length of their legs. They are above the average in height, yet the height is less than might be expected from their other skeletal measurements. That is, their bodies, excluding the long legs, are relatively short. Their breadth of foot, while above the average, does not seem to be significant, since it appears to be a function of their long legs and height rather than a distinctive characteristic.

"These conclusions may be checked by comparing these athletes with the non-track men who are like them in gross measures, to see if the above factors exist in the non-track men." [9]

C. *Skeletal Symmetries of Non-Track Group Above Mean.*

"To determine if the symmetries found among the track men would be found among non-track men who are above the mean in height, length of legs, and breadth of foot, sixteen men were selected at random from the non-track group and their skeletal measures applied to the three skeletal regression equations." [10] A summary of the findings is shown in Table IV.

Table IV contains similar material to that found in Table III. In addition, Table IV contains the height of jump attained by the individual, and the distance of the jump above or below the mean. Thirteen of the sixteen individuals jumped higher than the average of the group.

As noted in Table IV, some of the cases have minus residuals for height expectation and the others have plus residuals. "The same thing is true for expectation of length of legs and breadth of foot. Expressed in another way, some individuals are taller than would be expected from

[9] H. Krakower, *op. cit.*, p. 82.
[10] *Ibid.*, p. 82.

their leg length and foot breadth, and some shorter. This is also true of leg length expectation from the other two measures, some falling above and some below expectation. In prediction of foot breadth from height and leg length, some of the cases are larger than would be expected from the skeletal measures, and some smaller than would be expected.

"Since this tends to indicate that these same symmetries would not be found among the non-track group, it may be said that there are skeletal symmetries peculiar to the track group, and they are: long legs, a short body, and broad feet." [11]

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[11] *Ibid.*, pp. 82-83.

Some Correlations between Health, Intelligence Quotient, Extracurricular Activities, and Scholastic Record

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RECENT studies made on various phases of the health maintenance of members of the student body of Southern Illinois Normal University during the past five years (Hinrichs [6, 7, 8, 9, 10])* have brought to my attention some possible correlations between good health and certain other characteristics, such as scholastic records, intelligence quotients, and use of time outside of school hours. Two recent unpublished studies by members of the Department of Physical Education for Women have indicated that there is "some connection between general motor ability, intelligence and nervous stability," (F. Etheridge [2]) and between reaction time and motor ability (Snyder [14]). Other investigators have attempted to correlate physical fitness and scholastic standing, among them Giauque [5] and Ilsley [11] both of whom found little or no direct correspondence between health and scholastic attainment.

A recent timely commentary on the types of standards frequently used in judging physical fitness stresses the importance of bearing in mind the relative difference in effectiveness of two totally different types of condition in determining fitness for participation in certain activities, namely "static" and "dynamic" (Kessler[12]). The "static" type includes such nonremediable conditions as have become a permanent phase of the subject's physical equipment and for which he has been able to make satisfactory compensation but which do not in any way hinder his effective pursuit of a livelihood, e.g., unilateral lameness. On the other hand, "dynamic" factors are those which are frequently described as acute or chronic debilitating conditions and as a result of which the subject is physically handicapped and is frequently or continuously under par. These conditions (as exemplified by recurrent malaria, recurrent appendicitis, organic cardiac disease, gastric ulcer, etc.) do affect the satisfactory pursuit of certain types of work.

* Superior figures refer to numbered Bibliography at end of article.

In its present program of freshman orientation, (Bowyer [1]) and in the work of its Personnel Council, S.I.N.U. is attempting to analyze all potential factors which might enter into and modify the successful pursuit of a college career. An effort is being made to fit the curriculum to the student rather than the student to the curriculum.

My first studies were made on members of the freshman class only and were begun after the reports from all sources had become available, during the summer of 1937. Very soon, however, during the course of this study, it was decided to extend the work to the sophomores and upper classmen as well. Except for the fact that there were no records available for I.Q. values for members of the junior and senior classes at that time, the data are comparable and were statistically treated for all classes.

METHODS

Each student was represented by a card upon which were recorded the following facts: name, class status, sex, age, period of attendance in school, whether the student worked on NYA or State projects, whether he commuted or lived in Carbondale, his health history before coming to Carbondale (A), and his health record during his attendance throughout the period of study (B), his participation in extracurricular activities, his scholastic record, and his I.Q. rating at the time of college entrance.

COLLECTION OF DATA

Most of the data used were furnished by the Administrative Offices, the Student Employment Office, and officers of the various student organizations.

Health data were obtained from two sources:

A. From the physical examination and history card.

B. From the record of complaints and illnesses during the time covered by the period of this study.

Health scores were evaluated by assigning arbitrary values to each complaint or illness as suggested by McCloy[13] and as physical defects were evaluated mathematically according to severity, chronicity, and remediability, the total number of points so obtained was subtracted from 100 to give the health score. There have been various other attempts made to evaluate a health score, but that of McCloy with some slight modifications seemed best suited to this particular study.

Extracurricular activities included participation in one or more of approximately forty school activities (varsity or inter-scholastic athletic contests, music, dramatics, art groups, debates, enrollment or leadership in fraternal or other school organizations, etc.). Here again arbitrary values were used to designate the degree of participation in such activities. These values were assigned by a faculty committee.[3, 4]

Scholastic records were evaluated on the grade-point system and were classified into three groups: those with less than 2.5 grade points (D or E average, these students were on probation), a 2.6 to 3.9 grade point (C– to C + average), and those with 4.00 grade points or better (B or A average). The I.Q. data were collected at the time of freshman examinations, preliminary to college entrance.

DATA

On the basis of scholastic records, tables were made as follows: Values for the characteristics named above, such as extracurricular participation, I.Q., health, etc. were tabulated by groups, viz., according to class rating, according to Intelligence Quotient range, and according to scholastic record. In the statistical treatment of these values each characteristic was considered as a point of reference for each of the other characteristics. Accordingly, there have been developed tables con-

TABLE I

THE RELATION BETWEEN INTELLIGENCE QUOTIENTS AND SCHOLASTIC RECORDS

A. Intelligence Quotients 110 or higher

	Freshmen			Sophomores		
	Scholarship rating*			Scholarship rating*		
	a. Low	b. Average	c. High	d. Low	e. Average	f. High
Mean I.Q.	117	113	118	116	116	117
Mean deviation	4.00	3.30	3.40	2.18	3.49	3.40
Standard deviation	4.80	4.47	4.47	2.83	4.12	4.58
Range of I.Q.	111–128	112–125	111–132	111–120	111–126	111–130
Number of cases	21	52	52	11	37	41
Per cent of cases	16	42	42	12	42	46

B. Intelligence Quotients below 90

	Freshmen			Sophomores		
	Scholarship rating*			Scholarship rating*		
	g. Low	h. Average	i. High	j. Low	k. Average	l. High
Mean I.Q.	85	87	85	87	86	..
Mean deviation	2.96	2.25	..	1.95	2.00	..
Standard deviation	3.61	3.87	..	3.00	2.65	..
Range of I.Q.	75–89	74–89	..	77–89	81–89	..
Number of cases	25	12	1	20	8	..
Per cent of cases	73	25	2	71	29	..

* Scholarship rating—low = less than 2.5 grade points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 grade points or better (B or better)

taining averages, the mean, the range, mean deviation, and standard deviation. The coefficient of correlation, together with probable error, were calculated for each set of data. Data for both sexes were listed together since there was little significant difference between their separate scores. A complete series of calculations was tabulated for the age factor, but since there seemed to be no significant correlation, the data on this factor were omitted in the final compilation of results. (See below.)

Table I is a comparative study of I.Q. ratings of Freshman and Sophomore Groups and the relation of these to scholastic records. Since both of these groups were examined under similar conditions at the time of college entrance although a year apart, there was little significant difference between the I.Q. findings for the two groups.

From a study of Table I it will be seen that the percentage distribution of cases within the scholarship groups (low, average, and high) was closely parallel for the two classes. As expected, among the students with high I.Q. ratings the greater proportion of cases (84 per cent, b + c, Table I, and 88 per cent, e + f, Table I) had an average or better than average scholastic record in both classes, and in the group of students with a lower I.Q. rating the greater proportion in each of the two classes (73 per cent, g, Table I, and 71 per cent, j, Table I) made poor scholarship records.

As above stated, these results were expected. But the greatest interest was found in an effort to attempt an explanation of why all students with a high capacity for learning should not make good scholastic records or conversely why students with a low capacity should be able to compensate enough to make average or better than average scholastic records.

Accordingly, other characteristics of these groups were sought for. The first of these was a study of the use of students' time other than that devoted to regular school work. Obviously it was possible to make only a partially satisfactory study in this field, since many students spent time at pursuits other than those for which data could be collected. Records were obtainable only for students employed on NYA or State projects, and for students who commuted to and from their homes. The data are necessarily somewhat incomplete, in that some students worked longer hours than others and reports on employment off-campus were not available. Also some students had to spend more time in commuting than others. With these irregularities in mind, however, it was interesting to note whether any correlation existed between scholastic record and time spent in working or commuting. Table II shows the results of such a study.

Table II shows the grouping of students (number–A, B, C, and per cent–D), according to their use of time spent in working on campus or

in commuting to and from their homes. It will be seen from Table II D that among the high I.Q. group (Freshman) a small—almost negligible—difference exists between the percentage of students who are

TABLE II

THE RELATION BETWEEN SCHOLASTIC RECORDS AND NUMBER OF STUDENTS WORKING OR COMMUTING

	A. Number of Students Working			B. Number of Students Commuting		
	Scholarship rating[1]			Scholarship rating[1]		
Intelligence Quotient	a. Low	b. Average	c. High	d. Low	e. Average	f. High
Freshmen						
110 or Higher	7	14	18	3	4	5
90–110	26	34	11	11	13	5
Less than 90	4	6	0	4	0	0
Sophomores						
110 or Higher	1	16	13	1	2	3
90–110	11	26	12	3	8	5
Less than 90	6	4	0	1	1	0
*Juniors and Seniors**	13	21	40	10	9	11

	C. **Total Number of Students Studied			D. Per cent of Total Number in Each Group Either Working or Commuting		
	Scholarship rating[1]			Scholarship rating[1]		
Intelligence Quotient	g. Low	h. Average	i. High	j. Low	k. Average	l. High
Freshmen						
110 or Higher	21	52	52	48	35	44
90–110	125	114	43	28	41	37
Less than 90	25	12	1	32	50	0
Sophomores						
110 or Higher	11	37	41	22	49	39
90–110	44	85	41	32	40	41
Less than 90	20	8	..	35	63	0
*Juniors and Seniors**	57	74	137	40	41	37

* No I.Q. Records available at the time of study.
[1] Scholarship rating—low = less than 2.5 grade points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 or better grade points (B or better)
** Includes A, B, plus those students not working or commuting.

working or commuting and doing poor scholastic work (48 per cent, j, Table II) and the percentage who are working or commuting and doing excellent scholastic work (44 per cent, l, Table II). Among both Fresh-

men and Sophomore students with an average I.Q. (90-110) the difference was likewise not marked. This suggests that compensation has been made by able students who find that they must necessarily spend time and energy in either of the above ways and the effect on the scholastic record is negligible. On the other hand, among students with low I.Q. values (less than 90) in both Freshman and Sophomore classes, the incidence of poor work among working and commuting students is relatively high—32 per cent, j, Table II, and 35 per cent, j, Table II, respectively while 0 per cent, l, Table II, in each class were able to make an "honors" rating.

We must note also, however, in passing that students employed by the college, on either NYA or State projects are required (a) to have a satisfactory scholastic record before being employed and, (b) to maintain this record during employment. The combination of a heavy program of school work and much outside time and energy spent in working or commuting implies in addition good health and good hygiene to maintain a satisfactory school record. Further study of the use of student time was made on the basis of an analysis of participation in extracurricular activities. Results of this study are found in Table III.

Table III shows the relation between scholastic records, I.Q., and participation in extracurricular activities. While the mean values in the various groups do not vary greatly, there is a slightly higher mean value among students with high or average I.Q., in the higher scholarship brackets. The mean and standard deviations and range are also greater in these groups. There is a suggestion that within the groups as listed, the students with the better scholarship records also find time for greater expression of interest in extracurricular activities either in their own major field of study or in any of the forty or more social or professional groups. Among students of average intelligence the mean score for participation in extracurricular activities was relatively high. Low scholarship groups on the whole showed a lower mean participation in extracurricular activities. Among the low I.Q. groups of both classes, those students making the lowest grades showed greater mean and standard deviations than those of average scholarship. In individual instances, however, it was also noted that a few students with low I.Q. rating and low scholarship average were guilty of overparticipation in extracurricular activities, with a consequent drain on their study time, and without the capacity or desire for compensation for their innate lack of ability or interest in their studies—but more of this later.

One other factor studied was the age of students in various groups. It was found to have little if any significance. Data are not included in the final analysis.

However, it was found that the greatest range of age occurs in the

TABLE III

THE RELATION OF SCHOLASTIC RECORDS TO INTELLIGENCE QUOTIENTS AND TO PARTICIPATION IN EXTRACURRICULAR ACTIVITIES

A. Intelligence Quotients 110 or Higher

Extracurricular participation—Scores[1]	Freshmen			Sophomores			Juniors and Seniors		
	Scholarship rating*			Scholarship rating*			Scholarship rating*		
	a Low	b Average	c High	d Low	e Average	f High	g Low	h Average	i High
Mean	10	8	14	9	19	19	13	15	22
Mean deviation	8.50	6.58	10.81	8.64	14.81	14.12	12.37	11.27	17.84
Standard deviation	9.00	8.83	14.11	9.33	19.13	17.27	17.58	15.23	25.00
Range	0–47	0–35	0–65	0–23	0–97	0–64	0–86	0–67	0–160
Number of cases	21	52	52	11	37	41	57	74	137

B. Intelligence Quotients 90–110

Mean	8	9	8	10	10	13			
Mean deviation	6.43	7.82	7.86	7.48	7.89	9.80			
Standard deviation	7.94	9.85	10.25	8.72	11.18	14.32			
Range	0–37	0–52	0–38	0–30	0–73	0–65			
Number of cases	125	114	43	44	85	41			

C. Intelligence Quotients Less Than 90

Mean	8	15	3	12	8	..			
Mean deviation	8.00	7.60	..	8.85	6.50	..			
Standard deviation	10.49	8.06	..	11.53	7.48	..			
Range	0–30	0–53	..	0–37	0–21	..			
Number of cases	25	12	1	20	8	..			

* Scholarship rating—low = less than 2.5 grade points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 grade points or better (B or better)

1 The degree of participation in extracurricular activities is reported under extracurricular participation scores which are determined by adding arbitrary values ascribed to participation as a member or an officer in social or scholastic groups or for participation in athletics, debate, musical groups, etc.

Junior-Senior group. The obvious explanation for this is the fact that many of these students have returned after a period of teaching. In competition with some of the younger students these students may make a better scholastic record. On the whole, however, age within the limits found in these groups appears not to be a significant factor in modifying scholastic activity.

One other characteristic studied was health A (history and examination), and B (record of daily health while in attendance at S.I.N.U. during period of study). Table IV shows the results of these findings.

In Table IV, it will be seen that without exception the mean of health score B is considerably greater than the mean of health score A, which suggests that there may have been an average improvement in the health of individual students during the time covered by the study. However, this is not exactly complete since much of the information obtained from the student's personal health history is inaccurate due to such factors as inadequate information or desire to withhold information for various reasons. Also, the score B is based only on the conditions reported to our office and need not necessarily therefore include *every* illness, e.g., frequently students do not report colds, each of which would detract from health score B. Also many remediable defects entering into score A have been corrected and no longer enter into score B. For the above reasons, also the range is greater and the mean and standard deviation less for score A than for score B. This is true for all three classes.

It must also be noted that within a group, there is no significant or consistent difference in values for the various scholarship ratings or I.Q. groups. Apparently from these values for the groups of students studied, "health" is not a significant factor in the maintenance of scholarship or in association with the various I.Q. ratings. However, it must again be noted that in many individual instances, poor health was obviously a single contributing factor in the continued maintenance of poor scholarship rating. Let me recall to your attention the distinction between static and dynamic factors recently made by Kessler [12] to which reference was made in the introduction.

Statistical Consideration. Data were treated statistically, and the co-efficient of correlation calculated according to the Pearson Formula: $r = \frac{\Sigma xy}{n.dx.dy}$. In a study made by L. L. Thurstone,[15] the following statement was made: "Correlations between intelligence tests for college students and their scholastic standing are lower than the co-efficients found in the high schools and grade schools. The primary reason for this is probably that college students represent on the average a selected group with a restricted range of mentality toward the upper end of the scale."

1 The degree of participation in extracurricular activities is reported under extracurricular participation scores which are determined by adding arbitrary values ascribed to participation as a member or an officer in social or scholastic groups or for participation in athletics, debate, musical groups, etc.

TABLE IV

THE RELATION OF HEALTH, INTELLIGENCE QUOTIENTS, AND SCHOLARSHIPS

*Health A and B**

	Freshmen			Sophomores			Juniors and Seniors		
A. Intelligence Quotients 110 or Higher									
	Scholarship rating[1]			Scholarship rating[1]			Scholarship rating[1]		
	Low	Average	High	Low	Average	High	Low	Average	High
Mean—A Health Score...	88	86	86	90	86	87	84	84	83
B Health Score.	94	93	95	97	94	95	93	92	93
Mean deviation—A.....	6.00	5.26	6.46	7.09	6.14	5.90	6.01	7.34	7.11
B.....	3.57	3.66	4.06	2.45	4.35	3.90	4.33	4.08	4.49
Standard deviation—A...	7.87	6.71	8.00	8.72	6.93	7.21	8.06	8.54	8.72
B...	4.80	4.36	5.00	2.83	5.00	5.39	5.39	5.10	5.29
Range—A.....	63–100	65–100	67–98	69–99	71–98	70–98	62–99	68–100	62–100
B.....	86–100	85–100	78–100	92–100	82–100	74–100	74–100	83–100	73–100
Number of Students in Group—A.....	21	52	52	11	37	41	57	74	137
B.....	21	52	52	11	37	41	57	74	137

(*Continued on p. 237*)

TABLE IV (Continued)

B. Intelligence Quotients 90–110									
Mean—A Health Score...	83	84	87	87	89	86			
B Health Score...	94	95	94	94	95	95			
Mean deviation—A.....	6.58	6.62	6.26	5.55	5.44	4.54			
B.....	3.77	3.85	4.28	2.36	3.39	3.59			
Standard deviation—A...	8.12	8.00	7.81	6.86	7.21	6.00			
B...	4.80	5.00	5.92	3.87	3.74	4.47			
Range—A.....	57–98	58–99	68–100	64–99	69–95	69–94			
B.....	79–100	80–100	65–100	84–100	74–100	83–100			
Number of Students in Group—A.....	125	114	43	44	85	41			
B.....	125	114	43	44	85	41			
C. Intelligence Quotients Less Than 90									
Mean—A Health Score...	83	91	97	87	84	83			
B Health Score...	93	95		95	96	95			
Mean deviation—A.....	7.48	9.00	..	5.15	6.13	..			
B.....	5.48	3.50	..	3.60	4.38	..			
Standard deviation—A...	9.05	13.71	..	7.81	7.14	..			
B...	6.32	4.24	..	5.20	5.29	..			
Range—A.....	65–96	54–91	..	60–97	72–94	81–84			
B.....	78–100	88–100	..	81–100	85–100	93-97			
Number of Students in Group—A.....	25	12	1	20	8	2			
B.....	25	12		20	8	2			

* Health A refers to health history and physical examination record.
Health B refers to daily health record during period of study.
[1] Scholarship rating—low = less than 2.5 grade points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 grade points or better (B or better)

When the accumulated data are treated statistically and coefficients of correlation are sought for the various factors involved, it will appear that there is little of significance to be noted in a group study.

TABLE V
COEFFICIENTS OF CORRELATION

	Scholarship rating*		
Scholarship	Low	Average	High
and I.Q.[1]	.0020 ± .0027	.0023 ± .0022	.0047 ± .0038
and Health A	.0025 ± .0022	.0018 ± .0018	.0015 ± .0021
and Health B	.0025 ± .0022	.0019 ± .0018	.0016 ± .0021
and Extra-curricular activities	.0018 ± .0022	.0016 ± .0018	.0014 ± .0021

* Scholarship rating—low = less than 2.5 grade points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 grade points or better (B or better)

[1] Total of 732 students. Calculations for other factors are based upon data from a total of 1000 students.

Table V shows the correlation coeffiicients with their probable error for the above factors. From a study of this table it will be seen that the significance of the correlation coefficient is obviously based on the size of the group under consideration and that for groups of comparable size, while none of the findings for correlation values are significantly high, there is a slight suggestion that in the group represented by students with high I.Q. a greater correlation appears between scholarship and I.Q. than in any of the other groups.

It appears from the above studies that a more satisfactory estimate of relations of the above-named characteristics can be obtained by studying *individual* records and trying to decide what may be the most probable cause contributing to an individual student's failure. Accordingly, the data were again scrutinized as shown in Table VI.

Table VI shows the results of analysis of possible factors modifying the success or failure of individual students. The number of students in each group, their I.Q. level, and scholarship rank (columns a to f) are grouped according to two factors, viz., the use of after-school hours (a, b, and c) and health (d and e), and another group in which no apparent cause could be found modifying scholastic attainment.

Without exception, health was found to be an important factor in modifying scholastic standing, for within each I.Q. range, low health scores were found among the largest proportion of the students with low scholarship ratings. This does not hold in the group with intelligence quotients below ninety, which in itself may be sufficient cause for low scholarship in most cases. This suggests that these groups of students were unable to compensate for their lower I.Q. capacity because of health deficiencies. The use of after-school time for working, commuting, or extra-curricular activities was another factor obviously influencing scholastic standing. The effect is especially marked in the average and low I.Q. groups.

TABLE VI

A STUDY OF THE CAUSES MODIFYING SCHOLARSHIP RANKING OF INDIVIDUAL STUDENTS

	The Use of After-School Hours									Health						No Obvious Cause for Scholastic Failure			Total Students in Each Group
	a Number of Students Commuting or Working			b Number of Students With High Score for Extra-Curricular Activities			c Column a or Column b and One Other Cause			d Number of Students With Health Score Less Than 90			e Column d and One Other Cause						
Scholarship Rating[1]	*F	S	JS	F	S	JS	F	S	JS	F	S	JS	F	S	JS	F	S	JS	
A. Intelligence Quotients 110 or Higher																			
Low	3	..	..	1	7	..	..	4	..	11	5	..	10	3	..	4	1	..	49
Average	..	2	..	1	1	..	3	..	..	1	1	..	2	3	..	2	1	..	17
High	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	2
B. Intelligence Quotients 90–110																			
Low	12	4	..	10	4	..	12	6	..	47	14	..	29	9	..	17	8	..	172
Average	12	4	..	13	4	..	4	10	..	26	13	..	38	24	..	18	22	..	188
High	2	4	..	2	6	..	4	3	..	14	11	..	14	22	..	6	3	..	91
C. Intelligence Quotients Less Than 90																			
Low	4	..	..	1	3	..	2	1	..	4	4	..	8	..	..	3	3	..	33
Average	1	5	..	7	5	..	4	1	..	19	8	..	9	15	..	9	2	..	85
High	6	4	..	6	7	..	5	4	..	10	5	..	19	12	..	6	10	..	94
D. No Intelligence Quotient Values																			
	..	..	21	..	..	36	..	..	44	..	..	55	..	..	76	..	..	..	232

[1] Scholarship rating—low = less than 2.5 points (D or less)
average = 2.6 to 3.9 (C)
high = 4.00 grade points or better (B or better)

*F = Freshmen
S = Sophomores
JS = Juniors and Seniors

It is apparent that while the factors mentioned above may in individual cases explain the surprise success or failure of students in their scholastic work, there is no justification for any statement regarding a group study of these factors. For example, a student with moderate or less than average intelligence who finds it necessary to commute, may put forth greater concentration of effort and due to the possession of good health or good health habits compensate to such a degree as to place himself in the group with students doing average work. Again, on the other hand, a student with superior intelligence rating may by undue participation in extracurricular activities, by lack of concentration or interest in scholastic work, by poor health or poor habits, be found in the group making a poor scholastic record.

CONCLUSIONS

I do not believe that, all things considered, any generalizations can be made regarding group records of any of the factors stated above. The standing of the student will obviously be an *individual* matter and will be based upon his desire or ability to compensate for any of the possible deterring factors in his school career.

The statements just made are probably justifiable conclusions arising from facts obtained in this study.

1. In order to understand why students succeed or do not succeed, it is essential that each individual case be studied *as an individual* case, and

2. That frequent consultation be had with each student in order to determine which factors among those considered above may be significant in moulding a student's success or failure.

Accordingly, studies by a group constituted on the pattern of most personnel units may make the most significant contribution by contacts with individual students.

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Achievement Examinations in Badminton

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THIS study is a continuation of the work on achievement examinations. The first report was on written tests in swimming.[2] The second report included written and skill tests in tennis.[3] The badminton study includes written and skill tests.

The committee presents these studies for whatever worth the examinations may have in their present form for the college teacher. It is also hoped that they will serve as an incentive toward improvement of testing and as a suggestion of procedures to follow in evaluating new examinations.

PROCEDURE

The badminton study followed the same general plan as the two previous studies. A written examination was prepared and given a trial administration to a few badminton teachers and students. It was revised on the basis of their reactions to the items. The experimental form then consisted of 50 multiple choice and 39 true-false items. The skill tests in the experimental battery consisted of a service, and a clear test. (See Appendix for the description of tests.) These tests had been selected from a battery of six in a preliminary study.[4]

Eleven schools participated by administering the written tests, and five of those schools also gave the skill tests. These schools taught a badminton unit of 15 to 20 lessons, 30 to 40 minutes in each lesson. The returns included 149 beginners and 72 advanced players on the skill tests, and a total of 351 on the written test.

ANALYSIS OF DATA

The papers were marked as belonging to first term players, or to those with more experience, hereafter to be called advanced players. The first analysis of scores, however, showed the beginning group with a mean score of 53.4, and an S.D. of 6.3, while the more advanced group had a mean score of 54.1, with an S.D. of 6.7. It appeared, there-

[1] Other members of the committee working on this study are Aileen Carpenter, Esther French, Louise Kuhl.

[2] M. Gladys Scott, "Achievement Examinations for Elementary and Intermediate Swimming Classes," Research Quarterly, May 1940, p. 100.

[3] M. Gladys Scott, "Achievement Examinations for Elementary and Intermediate Tennis Classes," Research Quarterly, March 1941, p. 40.

[4] Esther French, "Skill Tests for Badminton," unpublished study, 1940.

fore, that the two groups were homogeneous with respect to information on the game and the papers were put into one group for analysis.

The index of discrimination, or the measure of validity of the individual item, is the same as that used in the previous studies.[5] Because the time required to compute a critical ratio for each item is prohibitive, the more practical procedure is to set an arbitrary and uniform value as being significant. Because of the great similarity in S.D. for each item this procedure is satisfactory. This value has been set in this study at 4. Computation of a few critical ratios on items indicated that this is sufficiently high. However, the few questions which fall between 4 and 6 have been starred. If it seems advisable to shorten the examination in any situation these are the logical ones to eliminate first.

The difficulty rating of the individual items shows, that in general, the questions are too easy. However, they are probably better in this respect than most examinations prepared for a specific class by the regular teacher. Also, the presence of numerous easy questions with a high index of discrimination does give good discrimination among the poorer students where it is very much needed if the tests are used for grading. The range of difficulty on this examination is better than in any of the four previous forms presented by this committee. It will also be noticed that the true-false questions are, in general, easier than the multiple choice, indicating a definite point in favor of the latter in test construction.

The final form of the examination contains 47 multiple choice and 33 true-false items. The reliability on 100 papers selected at random was computed by the odd-even method and corrected to actual length by the Spearman-Brown prophecy formula. The reliability coefficient on the multiple-choice items was .79, and on the true-false items .72. The reliability appears adequate in light of the heterogeneous background of the 350 players making up this group.

The grading scheme presented in Table III is based on the scores made by the entire group when the papers were re-scored on the final battery only. Differences from school to school will make it necessary to adjust this scale somewhat.

TABLE I

RELIABILITY OF SKILL TESTS

	Odd vs. Even	Spearman-Brown Correction
Service—beginners	.63	.77
Service—advanced	.77	.87
Clear—beginners	.82	.90
Clear—advanced	.95	.98

[5] Frances Swineford, "Validity of Test Items," *Journal Educational Psychology*, 27 (1936) p. 68. This study presents the original validation of this procedure.

TABLE II

CORRELATION COEFFICIENTS BETWEEN TESTS

	Preliminary Study	Beginners	Advanced
Service and clear tests	.11	.35	.43
Service and final form of written test	..	.25	.36
Clear and final form of written test	..	.30	.30
Service and subjective rating	.66	.43	.70
Clear and subjective rating	.60	.49	.56
Multiple correlation (clear and service with rating)	.85	.56	.75

In analyzing the skill tests the players were separated into the first term group; and the advanced or those with more than one term of playing. Players were given twenty trials on each test. The reliability coefficients on these twenty trials, ranging from .77 to .98 indicate excellent results in that respect. Study of the reliability on the alternate halves would indicate that ten trials would be sufficient with the exception of the service for beginners. Such a revision is therefore advised unless a great deal of time is available.

Subjective ratings on a seven point scale were secured from the instructor of each player taking the skill tests. Correlations between the tests and the ratings on this and the preliminary study are presented in Table II. The multiple correlations in both studies are also given. The rating in the preliminary study was a combination of subjective estimate and standings in tournament play. The more detailed and uniform rating of the preliminary study doubtless accounts for the higher coefficients. The higher multiple on the preliminary study is also due to this fact and to the unexplainable lower intercorrelation between the service and clear tests.

The regression equations were computed and simplified for each of the three multiple correlations. It will be noted that there is not much difference between them. Owing to the superiority of the method of rating in the preliminary study it was decided to use that formula (1. service + 1.2 clear) instead of those established on the respective groups. However all tests were scored by both formulas and the score correlated with the ratings. They gave almost identical results. This is to be expected since there are only two tests in the battery, one is kept at unity and the ratio of the second does not vary enough to alter the score significantly.

The grading scheme presented in Table III is based on the first formula. If the others are used the scores will fall into a different distribution. Also if the number of trials is cut to ten, as suggested, a new scale must be used, though the same formula will hold. A T-scale is also presented in the appendix. This may be found more useful in checking improvement and as a motivating device.

One other direct outgrowth of this study has been an evaluation of

TABLE III

SUGGESTED GRADING PLAN BASED ON ALL CASES IN THIS STUDY

Written Test*	Skill Tests	
	Beginners	Advanced
A 68–up 5%	A 115–145 ..... 5%	A 170–180 ..... 5%
B 58–67 .....24%	B 85–114 .....24%	B 110–169 .....24%
C 42–57 .....42%	C 40– 84 .....42%	C 55–109 .....42%
D 28–41 .....24%	D 15– 39 .....23%	D 25– 54 .....24%
Fd 27–down 5%	Fd 14– 0 ..... 6%	Fd 24– 0 ..... 5%

* Score = multiple choice items correct + (right — wrongs in true false)

the method of computing the index of discrimination. It was suggested in the tennis report (RESEARCH QUARTERLY, March, 1941) that the median might be substituted for the mean. Both measures were computed on each of the items. All but two of the items discarded by the mean would also have been discarded by the median, and no additional ones would have been eliminated by the median. Comparison of the two indices would indicate that the median might be used, though perhaps the value selected as significant should be slightly higher. The value of this substitution is obvious since the median is much more quickly computed than the mean, particularly when a frequency distribution of scores is made.

CONCLUSIONS

The following conclusions seem justified from the facts presented in this study:

1. The written examination is an adequate measure of knowledge of badminton.

2. The combined clear and service tests measure playing ability for the advanced player more satisfactorily than for the beginner, though they should be useful for both groups.

3. Ten trials is sufficient on each test, with the exception of the service test for beginners.

4. The median may be substituted for the mean in computing the index of discrimination.

APPENDIX

BADMINTON EXAMINATION

Part I. Each of these statements presents a situation which would require one of the four decisions listed below. In the blank space preceding each statement write the number which corresponds to the correct decision.

1. Point
2. Let
3. Side out
4. First down

Discrimination	Difficulty	Answer	
9.1	67	1	1. The receiver was not expecting the serve but attempted to play it, striking it into net.
3.9*	44	1	2. The receiver moves forward as soon as the bird is served and is at the net to drop the bird back as soon as it crosses the net.

* Items with a low index of discrimination are marked with the asterisk. These should be omitted if the examination is to be shortened.

7.8	69	*1*	3. *A* served, later returned the bird into *B's* court just out of *B's* reach, but, in making the stroke, the frame of the racket hit the bird.
14.7	87	*1*	4. *A* serves from the righthand court, *B* thinks it is short and doesn't play it. It falls on the intersection of the center and short service lines.
9.6	67	*1*	5. *A* is serving in singles. Bird goes over *B's* head and falls between the back boundary lines.
10.4	81	*2*	6. A spectator sitting near the side of the court drops a ball which rolls onto the court in front of *A* just as *A* serves a bird which goes into net.
8.9	67	*3*	7. *A* and *B* are playing singles. *A* served. Later, as *A* is making a drop shot, *A's* shoulder brushes the net, but the bird goes over the net and falls to the floor.
8.7	68	*2*	8. *A* and *B* are playing singles. *A* serves. Bird touches top of net and falls just beyond short service line.
8.6	52	*4*	9. Team *A* is serving in doubles. Score is 4-2. Bird goes high and falls between the back boundary lines.
9.3	54	*2*	10. Score is 5-2 in a doubles game. Server misses the bird entirely in attempting a serve.
9.5	66	*1*	11. In a doubles game the score is 5-1. The bird is ticked by the racket of one of the receiving side. Her partner plays it back across the net where it falls to floor between players of the serving side.
5.5*	44	*4*	12. In a doubles game the score is 5-1. On the serve the bird touches the net and falls into the alley between the short service line and the net.
7.7	58	*3*	13. In a doubles game the score is 5-1-1. Receiving side returns the bird so that it touches the top of the net and falls into right-hand alley between short service line and net.

Part II. Select the one item which best answers each question. Place the number of that item which you select in the blank preceding the number of the question.

13.6	91	*2*	14. How long do players play at one end of court? (1) change at the middle of every game, (2) change at the end of every game, (3) play the entire match from one end.
12.3	86	*2*	15. What does a down mean? (1) point, (2) player serving loses service, (3) opponents win right to serve, (4) point is played over.
12.5	34	*3*	16. How may a game not be finished if it reaches a score of 14-14? (1) by first player to win one point, (2) by setting game to 3, (3) by setting game to 5, (4) by players deciding whether to play for one point or to set game.
5.9	53	*2*	17. How many points in a game of mixed doubles? (1) 11, (2) 15, (3) 21, (4) players decide.
16.4	62	*3*	18. Where is home position in singles? (1) at intersection of center line and short service line, (2) at intersection of center line and baseline, (3) on center line midway between short service line and baseline, (4) in center of right or left court.
11.8	54	*1*	19. What is a team's term of service called? (1) inning, (2) ace, (3) down, (4) service.
6.9	64	*2*	20. If a preliminary rally is played to decide the server, how long must the rally last? (1) bird must cross the net at least two

times, (2) bird must cross the net at least three times, (3) each player must play the bird at least two times, (4) each player must play the bird at least three times.

17.3 98 4 21. How frequently should the score be announced? (1) at the end of each game, (2) whenever the score is tied, (3) whenever a player requests it, (4) after each point is played.

4.2* 83 3 22. How should you recover a bird which has fallen in the alley of an adjacent court where play is in progress? (1) reach in quickly with racket to roll it out, (2) run on to court quickly and dodge out of way, (3) wait on your own court until play is finished, (4) ask players to return the bird, (5) get a new bird.

3.7* 83 2 23. What lines run across the court on each side of net? (1) one short service line and one back boundary line, (2) one short service line and two back boundary lines, (3) two short service lines and one back boundary line, (4) two short service lines and two back boundary lines.

9.9 66 1 24. How does the length of doubles service court compare with that of singles? (1) shorter, (2) longer, (3) same, (4) players decide in each match.

7.2 88 1 25. What is the effect of calling a let service? (1) allows point to be played over, (2) gives server a score, (3) gives receiver a score, (4) gives service to the opponent, (5) counts as a down.

10.6 75 2 26. *A* and *B* are playing singles. *A* calls score of 7-4. From where will the next point be served? (1) *A's* right court, (2) *A's* left court, (3) *B's* right court, (4) *B's* left court.

10.1 46 5 27. Team *A* is playing doubles with team *B*. Server on *A* team calls score, love, one, one. What is the meaning? (1) first game *A* has one point, *B* has one point, (2) *A* has no points, *B* has one point on each of two terms of service, (3) *A* has no points, *B* has one point and one down, (4) *A* has one point, *B* has one point on a set game, (5) *A* has no points and one down, *B* has one point.

10.3 71 2 28. The score is 14 all. How may the game be set? (1) at two points, (2) at three points, (3) at five points, (4) can't be set.

10.5 53 4 29. *A* and *B* are playing, *A's* score is 13, *B's* is 12. *B* makes one more point and wishes to set the game. What may she do? (1) she may set it at two points, (2) she may set it at three points, (3) she may set it at five points, (4) she may not set it.

9.3 82 2 30. How many games are usually played in a match to determine the winner? (1) one, (2) two out of three, (3) three out of five, (4) sum of three games.

12.6 71 4 31. In singles when the serve returns to a player from where is the first serve played? (1) always from the righthand court, (2) always from the lefthand court, (3) from either court she chooses, (4) depends upon her score.

9.7 97 3 32. Where must the server stand when serving? (1) behind the baseline, (2) one foot on a boundary line of proper service court, (3) inside proper service court, (4) anywhere on court.

6.8 85 3 33. How long does a player serve in doubles? (1) only once, (2) until the team wins two points, (3) until the team has one down, (4) until the team has two downs.

8.9 43 3 34. What stroke of your opponents is likely to be weakest and therefore a desirable stroke to force her to use? (1) high overhead, (2) high forehand, (3) high backhand, (4) low forehand, (5) low backhand.

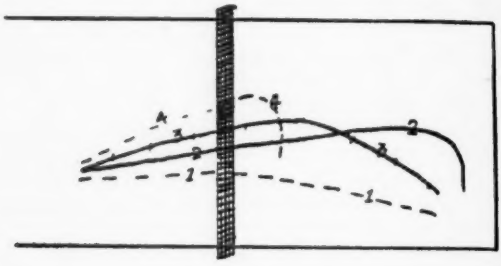
6.1 65 1 35. When returning a drop shot at the net at what point should you attempt to hit it? (1) while it is above level of top of net, (2) just after it drops below level of top of net, (3) about waist height, (4) as low as possible.

6.6 55 2 36. What is the chief difference in execution of a smash and a drop shot if each is played from high overhead? (1) length of preliminary swing, (2) follow through and wrist action, (3) direction of racket face, (4) speed of preliminary swing.

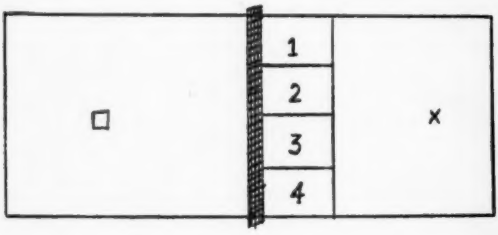
5.5* 88 1 37. What type of serve should be used most in a doubles game? (1) the one which causes opponent most difficulty, (2) the one which the server likes best, (3) anything except a short serve.

6.4 47 1 38. In what direction should the server face? (1) toward net, (2) toward right sideline, (3) toward left sideline.

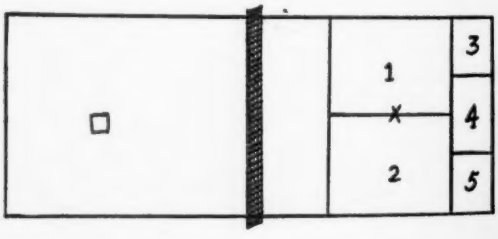
12.5 58 2 39. What is the path of the ideal clear shot?



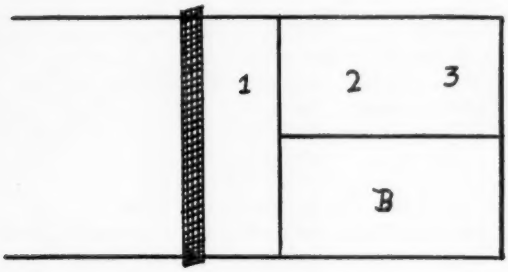
13.7 80 4 40. If you (□) are playing singles and wish to make a return into the front of the court, at which spot should you aim if the opponent is at (X) at the moment you prepare to hit?



12.0 68 5 41. If you (□) are playing singles and wish to use a clear shot, at which area would you aim with your opponent at (X) at the moment you prepare to hit?



7.2 41 2 42. *A* and *B* are playing doubles. In which position should *A* be if they are each playing their own half of court and *B* is ready to receive service.



8.9 61 1 43. Which side serves first in the second game? (1) side which won the preceding game, (2) side which lost the preceding game, (3) side which did not serve first in preceding game, (4) decide in same way as for first game.

11.1 81 3 44. In a singles game, *A* serves a bird which would have gone out of bounds. *B* returns it. What should *A* do? (1) play point over, (2) give *B* the service, (3) play the bird when it is returned, (4) claim a point.

6.8 75 3 45. Team is playing front and back style of teamwork. Which strokes will front player use most? (1) high clear, smash, (2) high clear, drop, (3) smash, drop, (4) drive, high clear.

5.3* 85 2 46. In singles play, where should the player wait for a return? (1) at intersection of short service and center line, (2) midway on center line, (3) at net, (4) where last stroke was played to avoid unnecessary running.

6.3 46 1 47. Where should the short serve be aimed? (1) corners of court, (2) midway of court near short service line, (3) at the receiver's feet, (4) behind the receiver.

Part III. Read each statement carefully. If it is entirely true, encircle the *T*, if it is partially or completely false, encircle the *F*. Do not guess.†

6.8 88 F 1. A toss of the racket is never used in deciding which player shall start service.

6.4 38 F 2. The winners of a match should be the first to thank opponents for the game.

5.1* 85 T 3. A spectator should not walk behind a court during a rally.

7.0 70 T 4. When playing on club or public courts, singles games should not be played if other players are waiting to play.

12.1 79 T 5. The doubles service court is wider than the singles service court.

7.3 80 T 6. A player loses the point if her racket touches the net.

4.1* 61 T 7. A receiver is not allowed to stand astride the center line while waiting for the service.

9.7 59 F 8. In doubles each team always has two downs before losing the service.

10.4 87 F 9. The winner of any game in which women are participating is decided by the winning of eleven points.

† In preparing examination papers, the letters *T* and *F* should precede the number of the question.

8.1	75	T	10.	In singles, the score is 8-5. The next point will be served from the righthand court.
8.6	93	T	11.	In serving, contact with the bird must be made below waist height.
13.7	81	F	12.	The player winning the toss or rally must serve first.
11.6	80	F	13.	A game cannot be set when the score is nine all.
8.2	77	T	14.	If a team declines setting the score at 13 all, they may do it later if opportunity is furnished properly at 14 all.
10.2	84	F	15.	Setting the score at 13 all is done exactly the same as 14 all.
5.8*	85	T	16.	Members of the serving team exchange sides of the court whenever a point is made.
6.4	71	F	17.	A player should take a step forward on one foot when serving, as it adds force to the serve.
5.4*	80	F	18.	When playing doubles, the server usually stands nearer the center line than she would if she were playing singles.
13.3	94	T	19.	A bird which falls on a line bounding a proper court is considered good.
14.5	95	F	20.	A player may hit the bird twice while making a return, providing the bird does not drop to the floor between hits.
9.1	78	F	21.	The best waiting position is with racket hanging at the side in a relaxed grip.
10.5	93	F	22.	All strokes except serve should be made while running.
5.3*	59	T	23.	Smashing straight down the court toward opponent is usually better than smashing slightly diagonally.
8.1	95	F	24.	Smashes can be used most effectively from the back half of the court.
8.5	78	T	25.	The kind of service used should be varied in a game.
5.7*	63	T	26.	The underhand clear shot gives the opponent more time to get ready for a return than the overhead clear does.
10.6	85	F	27.	In doubles, a return down the center line can be played most easily by the player in the righthand court.
5.3*	66	T	28.	The long high serve can be used most effectively in singles.
4.1*	93	T	29.	The "clear" is a good stroke to use when the opponent is near the net.
6.6	93	T	30.	The "drop" is a good stroke to use when the opponent is in the back of the court.
4.0*	67	T	31.	The "drop" stroke may be used to create an opportunity for a smash when the opponent is near the net.
5.3*	49	T	32.	It is a fault if at the moment the bird is hit any part of the head of the racket is higher than the server's hand holding the racket.
6.1	52	F	33.	In rotation style of doubles, players always move in a clockwise direction.

DIRECTIONS FOR ADMINISTERING BADMINTON SKILL TESTS

Necessary equipment shall include: New birds, two tightly strung rackets, regulation court, standards and net, a rope clothesline 24′ long, and lines 2″ wide, made with paint,† wherever necessary as indicated in the description of tests. No practice trials shall be allowed. All trials shall be given in succession for each test. Each trial is scored according to where the cork end of the bird first lands.

† Suggest you use show-card paint which can be washed from floor.

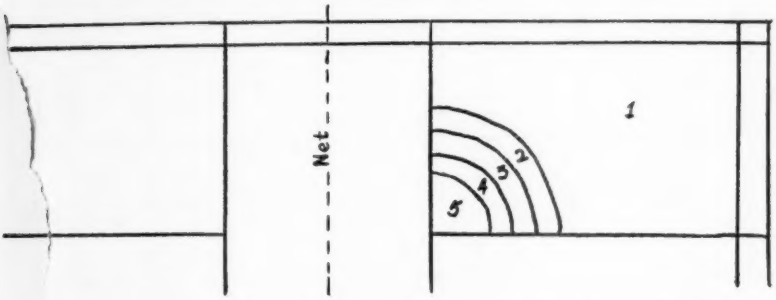
DESCRIPTION OF TESTS

SERVE TEST

Equipment.—

1. Clothesline rope stretched 20″ directly above the net and parallel to it, attached to the same standards.

2. Floor markings. Using the intersection of the short service line and the center line as a midpoint, describe a series of arcs in the right service court at distances of 22″, 30″, 38″, and 46″ from the midpoint, measurement including the width of the 2-inch lines at center and on the target. Extend these arcs from the short service line to the center line, as indicated in the diagram below. The lines should be painted in different colors to increase accuracy in scoring.



Test.—The player being tested shall stand any place in the service area diagonally opposite the target. She shall serve twenty birds, attempting to send them through the space between the rope and the net in such a manner that they land in the right service court for doubles game. The scorer shall stand near the center of the left service court on the same side of the net with the target and facing the target.

Scoring.—No score for any trial which fails to go between the rope and the net or which fails to land in service court for doubles game. Any bird landing within an area or on the line surrounding an area is scored as shown in the diagram. Any bird landing on a line dividing two scoring areas shall receive the score of the higher area. The score for the entire test is the total of twenty trials. It is considered a foul and the trial is repeated if the serve is illegal.*

Directions to Be Read to Players.—Stand anywhere you please in the right service court. Serve the bird across the net to the court diagonally opposite you in such a manner that it will pass between the rope and the net and land on the target. The corner of the target nearest you counts five points, the next space counts four points, the next three, the next two, and any bird off the target but in the service area for the doubles game counts one point. You will be given twenty trials.

CLEAR TEST

Equipment.—

1. A clothesline rope stretched across the court 14′ from the net and parallel to it, 8′ from the floor.

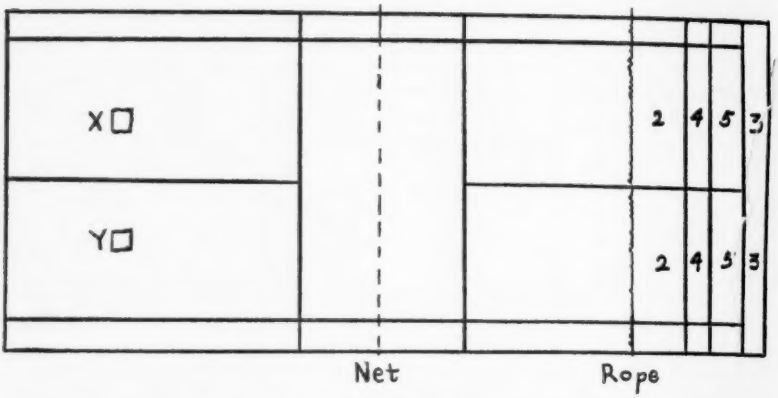
2. Floor markings.

a) Construct a line 2′ nearer the net than the rear service line in the doubles game and parallel to it. Measure from the exact center of line. Extend this line from one outer alley line to the other outer alley line.

* For definition of legal serve, see American Badminton Association Rules.

b) On the same side of the net, construct a line 2′ farther from the net than the rear service line in the singles game and parallel to it. Measure from the exact center of line. Extend this line from one outer alley line to the other outer alley line. The lines should be painted different colors to increase accuracy in scoring.

c) On the opposite side of the net, draw marks 2″ square at spots indicated on the diagram as X and Y. The center of X should be 11′ from the net and 3′ from the center line toward the left sideline. The center of Y should be 11′ from the net and 3′ from the center line toward the right sideline. In measuring from the center line, use the exact center of line.



Test.—The player being tested shall stand between the two square marks, on the court opposite the target. The person giving the tests (player with considerable experience) shall stand on the intersection of the short service line and the center line on the same side of the net as the target and shall serve the bird to the player being tested. The bird must cross the net with enough force to carry it to the line between the two squares before it touches the floor. (This is an imaginary line). If it does not go that far or is outside the space between the two squares, the player being tested should not play it. The player being tested may move any place she wishes as soon as the bird has been hit to her. Only birds played by the player being tested shall count as trials. She shall attempt to send the bird by means of a forehand clear stroke above the rope so that the bird lands on the target. Twenty trials. The person giving the test should call out the score of each trial, to be recorded by the assistant.

Scoring.—No score for any trial failing to go over the rope or failing to land in the court in the space behind the rope and on the target, as indicated on the diagram. Any bird landing within an area or on the line surrounding the area is scored as shown in the diagram. Any bird landing on a line dividing two scoring areas shall receive the score of the higher area. The score for the entire test is the total of twenty trials. It is considered a foul and the trial is repeated if the stroke is "carried" or "slung."*

Directions to Be Read to Players.—Stand between the two squares until the bird has been hit to you. Send the bird with a forehand clear stroke so that it goes above the rope and lands on the target. The area between the two rear lines of the regulation court counts five points, the space just behind it counts three points, the space just in front of the two rear lines of the regulation court counts four points. Any bird going over the rope but failing to reach the target counts

* See official A.B.A. rules for interpretation of terms.

two points if it lands in the court. You will be given twenty trials. The bird in being hit to you must go in the space between the two square marks and must be hit with enough force so that it does not reach the floor before it reaches an imaginary line between the two square marks. If you think that the flight of the bird is such that it will not meet these requirements, do not attempt to play it. It will not count as a trial unless you hit the bird.

TABLE IV

T-Scores of Skill Tests

Beginners		Advanced	
Score	T-Score	Score	T-Score
140	76	175	74
135	72	170	69
130	71	165	67
125	70	160	66
120	69	155	65
115	66	150	64
110	65	145	64
105	62	140	63
100	60	135	63
95	59	130	61
90	57	125	60
85	55	120	59
80	54	115	58
75	53	110	56
70	52	105	55
65	50	100	55
60	49	95	54
55	47	90	53
50	46	85	52
45	45	80	51
40	45	75	50
35	44	70	49
30	42	65	47
25	40	60	46
20	38	55	45
15	35	50	43
10	32	45	41
5	27	40	40
0	23	35	38
		30	37
		25	34
		20	33
		15	32
		10	31
		5	25

Study of the Effects of Competitive Basketball upon the Physical Fitness of High School Boys as Determined by McCurdy-Larson Organic Efficiency Tests

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HEALTH and physical educators throughout the country for many years have debated the advisability of permitting boys of high school age to compete in highly competitive athletics. A few articles have appeared during recent years in the press, popular magazines, and professional journals, either pointing out the dangers or else ridiculing the possibility of injury to the adolescent boy engaged in competitive athletics.

The purpose of this study is to determine, if possible, by means of the McCurdy-Larson Organic Efficiency Tests, the effects of competitive basketball upon the physical fitness of adolescent boys.

Basketball was selected as a basis of an activities test for the following reasons:

1. The National Federation of Secondary Schools reports, from a country-wide survey of public schools, that basketball leads all other activities as to numbers participating.

2. Basketball seasonal weight charts show a greater loss of daily weight than charts in any other sport on the scholastic program.[1]

3. Type of game: stopping, starting, change of direction, and continued play on hard, flat surface increases fatigue.[2]

4. Basketball has been found by Dawson,[3] and Henderson, Haggard, and Dolley[4] to be played usually under high temperature, humidity, and excitement. These factors have a tendency to decrease endurance in the players.

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[1] D. I. Allman, "Effects of Exercise on Bodily Weight," master's thesis, University of Michigan, 1931, 6.

[2] J. H. McCurdy and R. T. McKenzie, *Physiology of Exercise*, 158.

[3] Percy Dawson, *The Physiology of Physical Education*, 339.

[4] Y. Henderson, H. W. Haggard, and F. S. Dolley, "The Efficiency of the Heart and the Significance of Rapid and Slow Rates," *American Journal of Physiology*, 82 513–514.

5. The changes in basketball rules since 1931, including the ten-second zone and the elimination of the jump rule have speeded up the game.[5]

6. The intense interest of the adolescent in basketball aids greatly in student control and collecting reliable data.

This study was made on 300 high school boys of the fourteen- to eighteen-year age level from the factory, mercantile, and professional classes, selected from the Ann Arbor and Ypsilanti, Michigan, public school systems. The group represented an excellent cross section of American public high schools. After rigid physical examinations those who, in the opinion of the writer, were physically unsound were eliminated. The remaining number, consisting of 260 boys, were given the organic efficiency tests. The control group, representing 130 of this number, averaged a 3-hour weekly physical education class and volunteered to refrain from all competitive sports, especially basketball.

The other half, representing the experimental group, engaged in a carefully supervised daily program of competitive basketball under trained coaches for a period of five months. This group averaged one official game per week, played with outside teams and before spectators. Practice scrimmages averaged two per week. At the termination of the five-month training period both groups were rechecked on physical examinations and then were given a second Organic-Efficiency Test. The Index Scores of these tests were classified according to the McCurdy-Larson Organic Efficiency Rating Scale.[6]

In many quarters there is a great need on the part of the physician, health educator, and athletic coach for a reliable test that will measure in a scientific manner the physical fitness of the adolescent participating in competitive sports. McCurdy and Larson,[7] after years of protracted statistical study validating the reliability of their Organic-Efficiency Test, indicated that it would measure improvement in physiological fitness in individuals taking part in physical education activities. If this test is adaptable to the adolescent boy it should indicate the effect of competitive basketball upon the physical fitness of high school boys.

REVIEW OF LITERATURE ON PROBLEM

1. *Diastolic Pressure.*—The literature of the last twenty-five years shows that the diastolic pressure has been recognized consistently and increasingly as one of the most important tests of condition and organic efficiency. At least a dozen of our investigators and reporters in this field have furnished ample evidence of this fact.

As a result of research beginning about 1900, we have the following

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[5] Paul Fay and Lloyd Messersmith, "The Effects of Rule Changes upon the Distance Traversed by Basketball Players," RESEARCH QUARTERLY, 9:2 (May 1938).

[6] J. H. McCurdy and L. A. Larson, "The Reliability and Objectivity of Blood-Pressure Measurements," RESEARCH QUARTERLY, 6:2 (May, 1935) 1–10.

[7] E. C. Schneider, *Physiology of Muscular Activity*, 2nd ed., (1939), 321–24.

tests, each of which stresses the importance of blood pressure as an index of condition.

Tests of Cardiovascular Functions

1906—Crampton Blood Ptosis
1910—McCurdy Cardiovascular Test
1914—Meylan Cardiovascular Test
1914—Foster Cardiovascular Test
1917—Barringer Cardiovascular Test
1919—Barach Cardiovascular Test

Tests of Relationships Between Systolic, Diastolic, Pulse Pressure, and Pulse Rate

1913—Stone Cardiovascular Test
1906—Tigerstedt Cardiovascular Test
Earlanger, Hooker, Karpovich, Sheldon, Henderson,
Pulse Pressure × Pulse Rate Index
McCurdy and Larson,
Pulse Pressure × Pulse Rate — Diastolic Index
1920—Schneider Cardiovascular Test
1920—Pulse-Ratio Test
1922—Basal Metabolic Test
1931—McCloy Cardiovascular Test
1935-39—McCurdy-Larson Organic Efficiency Test

The general conclusions to be drawn from the study of the literature are (1) that reliability of blood pressure measurements has been gradually built up to its present high degree of accuracy during a long period of years, the whole process culminating in such tests as the McCurdy-Larson; (2) that the criteria established for these blood pressure measurements have indicated that the diastolic pressure (fourth phase) which indicates the minimum pressure is an index of the continual strain placed upon the arteries between each cardiac systole and is therefore of great value in determining physical condition or organic efficiency.

2. *Breath Holding.*—There seems to be a scarcity of literature on breath holding as a test. It was not until the flarimeter came into use that the test was placed upon a scientific basis.

During the World War, Lieutenant Colonel Martin Flack [8] of the Royal Air Force of England directed a set of physiological tests to detect flying stress and fatigue. The breath-holding test was conducted by having the subject seated and then instructed to expire once as deeply as possible and then to inspire fully and hold the breath as long as possible. The reason for giving up was carefully noted. Dizziness and blurred vision were considered unfavorable signs. The average time of the hold was sixty-nine seconds; the minimum, forty-five seconds.

[8] Edward C. Schneider, *Physiology of Muscular Activity*, 336.

At the present time the Prudential Insurance Company [9] considers the breath-holding test given with the flarimeter, and the Master-Oppenheimer Standard Step exercise, the most accurate and sensitive yet devised in revealing the presence of early circulatory impairment. The Prudential Medical Department has adopted this test in the examination of all its applicants for insurance.

3. *Pulse Rate.*—The practice of determining the heart rate is of recent origin. In ancient times the pulse was studied but apparently not counted, although this could have been done accurately, with the sand glass or water bottle. One of the early workers with pulse rate, as it is affected by exercise, was Bowen,[10] who charted and described the general alteration in pulse rate over a given period of time during exercise on a stationary bicycle.

4. *Pulse Pressure.*—Pulse pressure, as defined by Kimber and Gray,[11] is the difference between the systolic and diastolic pressures. It is an indication of (1) how well the heart is overcoming the resistance offered it; (2) how successfully it is driving the blood to the periphery; and (3) the condition of the arteries. Pulse pressure varies and is dependent upon (1) the energy of the beat; (2) the elasticity of the blood vessels; (3) the peripheral resistance; and (4) the quantity of circulating blood.

5. *Vital Capacity.*—Ever since physical measurements have been made on school children, vital capacity has been a popular as well as a scientific phase of the physical examination and cardiovascular functional test.

6. *Measurements of Organic Efficiency.*—It was in 1910 that McCurdy[12] announced his first cardiovascular test which laid the ground work for the organic efficiency tests that were to follow. Ten years later he developed a cardiovascular rating[13] for the measurement of physical fatigue and efficiency.

In May, 1933, McCurdy and Larson[14] made a study of the reliability and objectivity of blood pressure measurements for the following purposes: (1) to ascertain the accuracy of blood pressure measurement by arranging the "experimental conditions" in such a fashion that errors in readings would be due to the inaccuracy of the measurement rather than poor "experimental conditions"; (2) to validate a research problem under investigation by the authors in which blood pressures are found to be important in determining organic efficiency; (3) to deter-

[9] J. A. Palton, "Determining Circulatory Fitness," Prudential Insurance Company Medical Department Publication (June 1931) 849.
[10] Edward C. Schneider, *Physiology of Muscular Activity*, 2nd ed., 194.
[11] Kimber and Gray, *Textbook of Anatomy and Physiology*, 250.
[12] J. H. McCurdy, "Adolescent Changes in Heart Rate and Blood Pressure," *American Physical Education Review*, 15 (June 1910) 421.
[13] J. H. McCurdy, "A Cardiovascular Rating as a Measure of Physical Fatigue and Efficiency," *Journal American Medical Association*, 85 (1920) 1507.
[14] J. H. McCurdy and L. A. Larson, *op. cit.*

mine whether blood pressure tests can be taken with sufficient accuracy to serve as an index of physical condition.

7. *Basketball Participation by Adolescents.*—The National Federation of Secondary Schools reports, from a country-wide survey of public schools, that basketball leads all other activities as to the number of boys participating.[15]

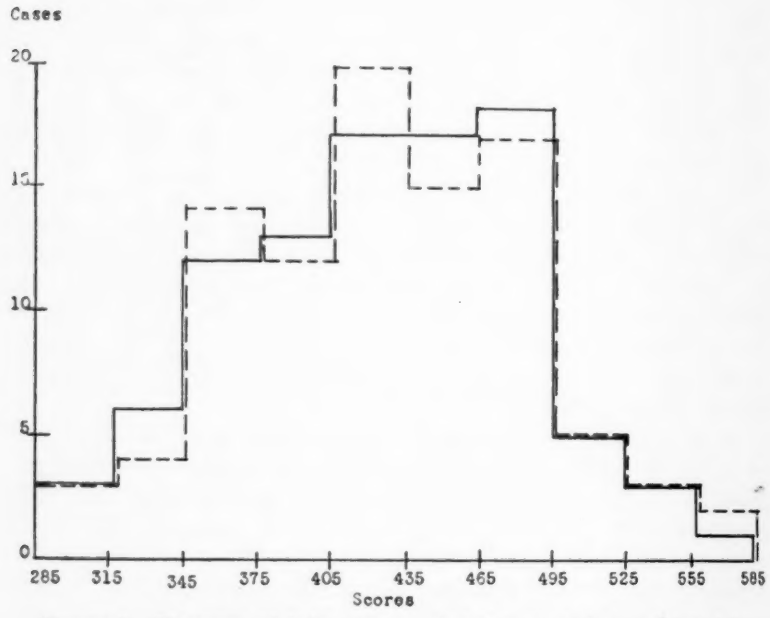

FIGURE I. Histogram of index score on first test; control group, dotted line; experimental group, solid line.

This histogram shows the range of organic efficiency found in the two groups, the relationship between the distributions, and also the degree to which the two distributions approximate the normal curve. A comparison reveals that the two distributions of organic efficiency are almost identical. This suggests that the sampling is probably adequate although there are only 190 cases.

SUMMARY OF REVIEW OF LITERATURE

The work of various authorities on cardiac functional tests and the effects of basketball on the adolescent may be summarized briefly according to the following fundamental statements:

1. The criteria established for blood pressure measurement indicate that the diastolic pressure (fourth phase) is an index of continual strain placed upon the arteries between cardiac systole and is therefore of great importance in revealing organic efficiency.

[15] F. R. Wegner, "What Age for High School Athletes?" *Scholastic Coach* (April 1936) 11–12.

2. Breath-holding test given with the flarimeter and standard step exercise reveals the presence of early circulatory impairment.

3. The pulse-rate test given before and two minutes after exercise is an important factor in indicating cardiac efficiency.

4. Individuals showing extremely low or high pulse pressures should refrain from strenuous activities.

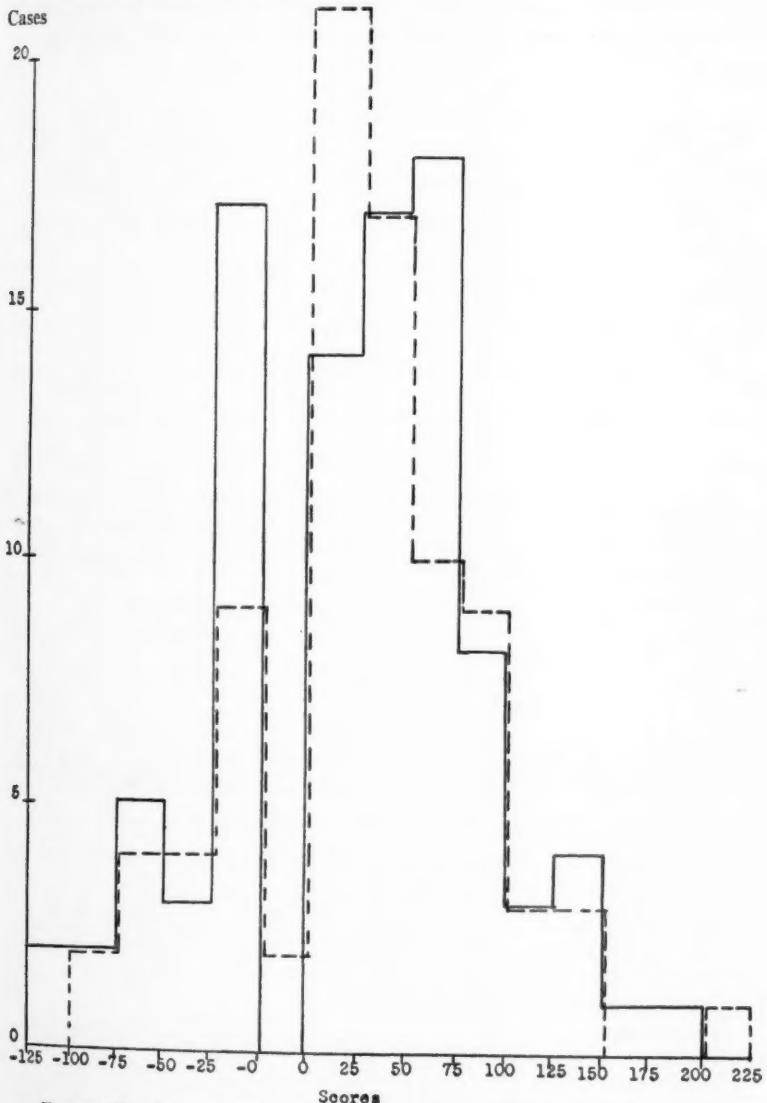

FIGURE II. Gains and losses in index scores between first and second tests; control group, dotted line; experimental group, solid line.

5. Vital capacity is a measure that does not determine the degree of respiratory efficiency and is the least important. It is primarily merely a size measurement.

6. Endurance is related primarily to circulatory and respiratory efficiency.

7. Basketball is not only one of the most strenuous sports on the interscholastic program but has the greatest attraction for participation of the adolescents and therefore should be very carefully supervised.

TABLE I

CORRELATION BETWEEN EXPERIMENTAL INDEX SCORES AND CONTROL INDEX SCORES, FIRST TEST, NOVEMBER 1–10, 1937, WITH DETAILS AND STATISTICAL MEASURES TO ILLUSTRATE PARTIALLY THE NATURE OF THE CORRELATION

Weighted T-Score Index Score	Mid-point	Frequency		Statistical Measures with Their P.E.'s	
		Control	Experimental	Control	Experimental
				Mean	Mean
555–585	570	2	1	426.00 ± 4.13	425.68 ± 4.07
				Q_3	Q_3
525–555	540	3	3	470.73 ± 5.63	470.41 ± 5.55
				Median	Median
495–525	510	5	5	425.25 ± 5.18	428.82 ± 5.11
				Q_1	Q_1
465–495	480	17	18	379.37 ± 5.63	381.34 ± 5.55
				σ	σ
435–465	450	14	17	±59.76 ± 2.91	±58.92 ± 2.88
				Coefficient of Variation	
405–435	420	20	17	14.02 ± .69	13.84 ± .69
375–405	390	12	13	Comparative Variability	
				1.01	.98
345–375	360	15	12	Correlation	
				+.988 ± .001	
315–345	330	4	6		
285–315	300	3	3		
		95	95		

For evidences of the nature of the relationship among the scores above, examine the two series of frequencies, corresponding statistical measures of both series, the mean and median of the control index scores, and the mean and median of the experimental index scores.

EQUIPMENT AND TEST PROCEDURES

1. *Equipment.*—The following standard equipment was checked for reliability before making this study:

Meylan stop watch (⅕ second double section)
Prudential stairs (two steps 9″ high)
Fleischer Stethoscope
B-D Sphygmomanometer with arm cuff
B-D Flarimeter
Charts:
Master and Oppenheimer (two-step exercise table)
McCloy (vital capacity table)
McCurdy and Larson (weighing table)

TABLE II

TABLE SHOWING CONTROL AND EXPERIMENTAL GAINS AND LOSSES IN INDEX SCORES BETWEEN THE FIRST AND SECOND APPLICATIONS OF THE ORGANIC EFFICIENCY TEST AND ALSO THE FINAL RELATIVE STATUS OF THE TWO GROUPS

Classifications	Group Per-Centile Rank	Gains						Losses						No Gains No Losses	
		Number		Points		Av. Per Cent		Number		Points		Av. Per Cent		Number	
		Con-trols	Experi-mentals	Con.	Exp.	Con.	Exp.	Con-trols	Experi-mentals	Con.	Exp.	Con.	Exp.	Con.	Exp.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Excellent.....	90	28	19	827	773	6.23	8.76	11	24	478	794	8.60	6.63	0	0
Very good.....	80	18	16	665	905	8.80	13.48	5	3	110	154	5.11	4.33	0	0
Good.....	70	10	13	587	886	15.16	17.62	1	1	10	7	2.53	1.86	0	0
Above aver.....	60	17	15	1048	1065	17.36	20.66	2	1	4	10	.55	2.69	0	0
Average.....	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below aver.....	40	1	2	66	109	21.43	17.93	0	0	0	0	0	0	0	0
Fair.....	30	2	1	282	61	47.77	21.71	0	0	0	0	0	0	0	0
Totals.....		76	66	3475	3799			19	29	602	965			0	
Averages.....				45.7	57.2	11.11	14.18			31.6	33.2	6.84	6.82		

	Con. 95 boys	Exp. 95 boys
Net Gains	2873	2834

Control Advantage..... 39
Total Index Scores Con. Group.....40,049
Total Index Scores Exp. Group.....40,822

Control Group Average Advantage
0.41 of one point

2. *Test Procedure.*—Previous to giving the organic efficiency tests to the experimental and control groups, the writer practiced for two months at the Michigan State Normal College Health Service in the use of the sphygmomanometer and stethoscope on college students. This practice was done under the supervision of a competent physician, with special emphasis on the taking of the sitting diastolic at the fourth phase. Following this practice, the writer gave thirty college athletes the McCurdy-Larson Organic Efficiency Test to acquaint himself with the technique of administering these tests. The results were treated statistically by the product-moment method of correlation to determine the reliability of the technique used.

The subjects for the tests came directly to the examination rooms, which were so located that none of the boys was compelled to climb stairs. A large number of the boys were in classrooms located on the same floor, therefore, physical exercise preceding the examination in all cases was reduced to a minimum.

Upon entering the waiting room their ages and weights were taken, after which they took chairs and were given an assortment of magazines that would appeal to boys of their age level. The subjects rested from five to ten minutes preceding the examination and every effort was made to exclude any physical exertion or mental excitement just before or during the tests. When the subject's turn came he was called into the examining room, seated in a chair near the table on which the sphygmomanometer and flarimeter were placed. During the time the cuff was being adjusted and inflated the examiner chatted with the subject in an attempt to put him at his ease and thus do away with the emotional element of apprehension as far as possible. The following technique was suggested by McCurdy-Larson in giving the tests:

a) *Record the date and the hour of examination.*

b) *Determine number of ascents on stairs.* Information obtained from table prepared by Master and Oppenheimer. Number of ascents is determined by age and weight of the individual.

c) *Secure sitting systolic and diastolic pressure.* (Fourth phase diastolic.) Measurements taken after a period of *one minute's rest* in a sitting position.

d) *Determine standing systolic and diastolic pressure.* (Fourth phase diastolic.) *One minute's rest* in this position before measurements.

e) *Determine standing pulse rate.* The pulse is taken for fifteen seconds and then multiplied by four. At least two consecutive measurements should be secured. In pressure and pulse-rate examinations, rapid change of posture should be avoided.

f) *Vital capacity.* Measurements are taken by the use of the flarimeter. The large orifice should be open for the measurement. The subject should inhale as much air as possible and then exhale into the mouthpiece, keeping the water level in the gauge at the black line. If

this is done it means the subject is exhaling at the rate of 200 cubic centimeters per second. The length of the blow should be timed in seconds, beginning approximately when the water level reaches the black line on the gauge. The subject should be encouraged to bring the water level up to this line as quickly as possible. Two trials should be given and the largest measurement should be selected. After each measurement, the temperature in the flarimeter should be read and recorded. In order to obtain the correct lung capacity it is necessary to multiply the length of the blow in seconds by 200 and add the temperature corrections. The correction necessary is obtained from McCloy's table. Suppose the subject exhales for 20 seconds and the temperature in the flarimeter is 23°C. The uncorrected vital capacity is 200 times 20, or 4000 cubic centimeters, or 4 liters. The correction to body temperature is made in the following manner. The temperature (23°) is found in the vertical column in McCloy's table, and the volume (4 liters) in the horizontal column. The point at which the two coordinates meet indicates the correction that is added to 4 liters (4000 c.c.). In this case it is .32, which gives 4.32 liters, or 4320 cubic centimeters.

g) *Trial blow in small orifice* (*flarimeter*). A practice blow should be given, using the small orifice. This is a measure of breath-holding ability and will be used in this test to determine the breath-holding ability after a standard exercise.

h) *Stair-climbing exercise.* The double-action stop watch should be used with one hand running continuously for this measurement and the two following (breath-holding and pulse rate). The number of ascents for this exercise is found in a table prepared by Master and Oppenheimer. The exercise, which should begin with the hands of the watch on 60, is continued for 90 seconds. If the number of ascents is 24, it means 8 ascents per 30 seconds. The examiner should count, with the subject ascending with the count. In going over the stairs, the subject should turn in the opposite direction when beginning the alternate ascents. This is to avoid dizziness. The last ascent should be complete at the end of 90 seconds or when the hands on the watch are at 30. The subject is then asked to sit close to the table on which the flarimeter is and breathe normally.

i) *Breath-holding 20 seconds after exercise.* Seventeen seconds after exercise (hands on watch at 47) the subject is asked to inhale once and blow into the mouthpiece of the flarimeter, keeping the water level on the black mark of the gauge. The subject should be encouraged to give as much as possible in the measurement. One of the two hands on the watch is stopped at the beginning of the blow and the time at the beginning of the blow recorded. This hand is then released and allowed to continue. At the end of the blow the hand is again stopped and the length of the blow recorded in seconds. One hand on the watch continues to move, which is necessary to obtain the pulse rate exactly

two minutes after exercise. At exactly 1 minute 45 seconds after exercise the subject is asked to stand.

j) *Determine pulse rate standing two minutes after exercise.* The pulse rate is taken for 15 seconds at exactly 2 minutes following the exercise (hands on watch will be at 30) and this value is multiplied by 4. The record is placed in the table.

k) *Method of scoring and classifying.* The organic efficiency test consists of five measures: sitting diastolic pressure, breath-holding 20 seconds after standard exercise, difference between standing normal pulse rate and pulse rate two minutes after exercise, standing pulse pressure, and vital capacity. The results of these five organic functional measures are inserted in Table under the column labeled "raw score." The "T-score $\times$ weighting" is then obtained for each measure from a table prepared by McCurdy and Larson. The sum of the five "T-score $\times$ weighting" values gives the "index score" for the organic efficiency test. The classification of the individual is obtained by referring to the classification table found in the table. Suppose the index score of an individual is found to be 360. This individual is in the "above average" classification.

l) *Second organic efficiency test.* At the termination of the five-month experimental period both groups were given an organic efficiency test again and the index scores classified in the table for this purpose. Then a re-check was made on the physical examination to determine any organic defects which might have developed. No subject was eliminated because of the re-check but several boys were lost at this point in the procedure from failure to refrain from competitive sports (control group), absences from school, or moving away from the community.

CONCLUSIONS

1. The McCurdy-Larson Organic Efficiency Test may differentiate among adolescent boys on a scale made by mature persons.

2. The test does not measure differences in condition demonstrably due to participation in basketball during a five-month period, so far as certain classifications are concerned.

3. Average group differences between first and second test are so small as to be without significance.

4. Irregular proportional development shown by correlations between first and second test scores eliminates the possibility of recognizing any differences in organic efficiency that may be due to basketball.

5. Physiological changes due to adolescence may be of such a nature as to eliminate the possibility of recognizing differences in organic condition that may be due to basketball in so far as the test is concerned.

6. Too much technical skill is required to make the test practical in the public schools.

7. Test reliability is secured only under the most favorable circumstances.

8. The sitting diastolic (fourth phase) test is the most valuable of all the tests used in this study.

9. The vital capacity test is the least valuable of all the tests used in this study.

10. Much scientific work must be done on the McCurdy-Larson Organic Efficiency Test before it can be used effectively with adolescents.

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Sources of Supplementary Materials for Health Instruction

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STATEMENT OF PROBLEM

INCREASINGLY teachers are using extra-textbook sources of health information to supplement standard materials and to increase student interest. Is this not as it should be? People live not in a world of textbooks and carefully selected collateral readings, but rather in a world of advertising radios, newspapers, and billboards; in a world of private and public agencies bent on serving or exploiting their needs; and in a world which demands that to live happily they must daily make wise choices between the more and the less useful in every realm.

The teacher who introduces his pupils to this real world and helps them to find their way about in it is genuinely preparing for real living. This is for the teacher no simple task. Nor is it the province of this paper to do more than provide him with certain information as to sources of material. Teacher and pupils must work together in selecting, securing, evaluating, and adapting the resources of society in relation to each specific problem as it is identified. They will be as critical of free materials as of those for which they must pay. The wise teacher will encourage his pupils to assume initiative at every possible point, but he will not in so doing ignore his responsibility for guiding the entire process to assure worthy outcomes.

HISTORY OF THIS PROJECT

In 1934 Mr. Raymond Roop (until his death in April of this year, physical director of the Y.M.C.A. of Los Angeles) while a student of health education with one of the present authors, undertook as a class project the preparation of a list of agencies that produce pamphlet and other materials of use in health programs. Since then this list has been thoroughly revised three times and supplemented by the present authors and their students. Undoubtedly it still omits some excellent agencies. It may include a few undesirable ones. Though the authors

have sought advice broadly from others, they cannot side-step the blame for imperfections. Such are in the last analysis indications of oversight, lack of knowledge, and imperfections of judgment in the authors who take this opportunity to invite concrete suggestions for future improvements in content and form. During its period of preparation the project has enjoyed a circulation of about 800 mimeographed copies and has been tested in many actual situations. For the present revision pamphlet material occupying more than six feet of shelf space has been collected, evaluated, and classified.

ORGANIZATION OF THE PROJECT

The materials here presented are organized in three parts. *Part One* is an alphabetic list of 150 agencies or agency groups. Each is given a reference number. These numbers are used in parts two and three. *Part Two* is an alphabetic list of health subjects. Each subject is followed by the reference numbers of agencies which have pamphlet or other materials for free or nominal cost distribution on this subject. *Part Three* lists various forms of health education materials such as pamphlets, films, posters, plays, and games. Under each heading are given the numbers of the agencies able to provide this type of material.

HOW TO USE THESE LISTS

An example will serve to illustrate the way in which these materials may be used.

The teachers charged with health instruction of girls in a junior high school in a middle sized city decided to devote the major portion of a semester to the subject of sex education. Wisely they chose to make this part of a larger subject, "Studies in Human Relationships." Informal discussion with a committee of girls selected for the purpose had led to the decision that, besides the general matters of sex instruction applicable to this age, the interest of the girls warrants some special attention to the problems of prenatal care, birth, parenthood, and care of the baby. Further it is decided to reserve discussion of venereal diseases for senior high school days when it will be included with other matters of public health. A small sum of money is available for postage, film rentals, and the purchase of some pamphlets. There are facilities for poster displays and bulletin board materials.

Careful perusal of Part Two, the alphabetic list of health subjects, shows under "Child Care and Education" eight agencies that have material in the area of Prenatal Care and four agencies in the area of Infant Care, three of which are duplicates of the former. In the section Diet Lists for Infants and Children under "Food," there are nine additional agencies listed. Under "Health," the section entitled Of Mother contains four agencies, two of which are not duplicated above while the section on Prenatal Care of Mother here lists seven agencies, one of

which is new to our total list. Since "Menstruation" is a special interest of this age group, we note two agencies in this area which are, by the way, the two great competitors in the field of sanitary napkins. One of them is listed also in Part Three as providing free poster or chart materials. The area of "Sex Education" lists twenty-four agencies, eight of which are already found in our list. Omitting duplications this search has uncovered thirty-nine distinct agencies, each of which may be expected to contribute to this program. Inquiry at the local Council of Social Agencies or comparable headquarters of the city's agencies will disclose additional organizations interested in these areas. Consultation with the school and city librarians may prove valuable. Many libraries have excellent collections of pamphlets.

Now comes the most important task. Teachers and pupils working together assign to various individuals the task of visiting or writing to the organizations on the list. One does not merely write, "Please send all information you have on health education to the undersigned. Respectfully yours, Jane Doe." This is the poorest sort of approach. Instead each letter or visit is carefully planned. Part Three is now also studied. Agency number 13 which appears four times in the list we have just prepared is found in Part Three to distribute pamphlets, films, posters, exhibits, plays, etc., at a small cost and is in position to give general advice or counsel. A letter to the American Medical Association would, therefore, include the following facts: first, a careful statement of exactly what the junior high school is trying to do, how many girls are involved and how much time is available; second, it would state that a small amount of money is available for pamphlets and rentals, that the high school has motion picture (indicate if silent or with sound) and slide projection equipment, and that posters and an exhibit (for one week) could be used to advantage if they were available; third, the letter would then ask the A.M.A. to advise what help the school could expect from it in connection with this program and how much it would cost. If this is the school's first contact with the A.M.A. the school doctor or another physician in the community should read the letter or, better still, help to construct it. Every letter, even when prepared by a committee of students, should be signed also by the teacher. Some organizations will not send materials without such a signature.

As a matter of principle a letter would be sent to the City or County Health Department and the State Department of Public Health located in the capital city. These letters would briefly state the nature of the proposed program and ask them if they have any literature or displays available in the field of sex education and the care of child and mother. Similar general letters should be sent to such federal agencies as numbers 56b, 133, and 142a which appear in the list of 39 agencies culled out of Part Two. Whereas federal agencies serve all

states equally, it is generally true that state, county, and municipal departments of health limit themselves to distribution within their own borders. Agency numbers in Parts Two and Three which are followed by the name of a city or state have unusually good materials and do send materials to other communities. It often happens that municipal, county, and state organizations distribute each other's or federal publications. To avoid receiving such material in duplicate it is wise to study sample materials before ordering large quantities.

A letter to number 104 could be a bit more specific. It might say, "In our junior high school we are conducting a health education program stressing the general aspects of sex education applicable to girls between the ages of eleven and fourteen. We are especially interested also in prenatal care of mother and child and in care of infants. Have you any pamphlets, film, or poster material in these areas which you could place at our disposal? Our school would be most thankful for any help you could give to us in the furtherance of our program." To such agencies as numbers 70 and 117 for instance, a much more specific letter is in order. It might read: "In our junior high school we are conducting a program of sex education for three hundred girls. We have heard that you distribute some excellent pamphlet material on the subject of menstruation. Would you kindly tell us how we could secure this printed matter for our girls? If by chance you have any sample material in this connection we could assure you that it would be distributed in accord with your instructions. Any other suggestions or advice which you might have for us will be gratefully received."

If an outside speaker is desired, consult the appropriate section in Part Three. Usually a personal interview preceded by a telephone call for an appointment and followed by a letter repeating the essential details is the best practice. The speaker is more likely to accept and do a good job if he is asked to speak on a definite subject and if he has been told about the entire program under way. The speaker deserves a pleasant and dignified introduction.

Thorough familiarity with the content of Parts One, Two, and Three and a little ingenuity will make it possible to write an individually adapted letter to each of the agencies. A good letter will begin with specific information and will ask for some specific help. After this it may close with a general request for any other related information or material. The results from such requests will be surprising. For a well conceived, earnest program of health education literally hundreds of pounds of printed matter will be delivered without cost to your door. Obviously this service which costs the donor considerable money places on the recipient the responsibility of distributing all materials wisely and conscientiously.

Most agencies, with the possible exception of the government printing office, will appreciate a thank-you letter and some remarks con-

cerning the way in which their materials were used. They will also be grateful for suggestions for improving their materials.

It will be noted that quite a few of the materials listed are produced by educational departments of business organizations. As such these are, of course, interested in creating an intelligent understanding about their products. Those which have been listed are believed by the authors to have worth-while material of educational value. The small pamphlets prepared by business organizations are often much more attractive and up-to-the-minute than are larger textbooks which do not meet as much criticism and competition. Some business organizations employ experienced specialists in nutrition and health education to prepare their materials. These deserve our full confidence. Some school systems may have special regulations concerning the use of materials from the business field. Such must, of course, be respected. Beyond this a wise teacher will be able to develop an enlightened attitude toward commercial agencies. This attitude should be broadly friendly rather than everlastingly suspicious. It should, however, understand that even insurance companies are in the field of health because the lengthening of life means increased income to them. Finally, it must be sensitive to recognize when the statements of fact begin to shade off almost imperceptibly into pressure for a particular product. This is in fact a necessary training for life.

PART ONE

An Alphabetic List of Agencies Able to Supply Health Instruction Material

1. Aetna Casualty & Surety Co., Hartford, Conn.
2. Allied Youth, Inc., 1201 Sixteenth St., N.W., Washington, D.C.
3. American Assn. for Health, Physical Education, and Recreation, 1201 Sixteenth St., N.W., Washington, D.C.
4. American Assn. of Medical Social Workers, No. Atlantic Branch, 428 W. 59th St., New York, N.Y.
5. American Automobile Assn., Pennsylvania Ave. at 17th St., Washington, D.C.
6. American Dental Assn., Bureau of Public Relations, 212 E. Superior St., Chicago, Ill.
7. American Dietetic Assn., 183 N. Wabash Ave., Chicago, Ill.
8. American Eugenics Society, 1790 Broadway, New York, N.Y.
9. American Foundation for the Blind, 15 West 16th St., New York, N.Y.
10. American Genetic Assn., Room 308, Victor Bldg., Washington, D.C.
11. American Heart Assn., 1790 Broadway, New York, N.Y.
12. American Home Econ. Assn., 620 Mills Bldg., Washington, D.C.
13. American Medical Assn., Bureau of Health Education, 535 N. Dearborn, Chicago, Ill.
14. American Museum of Natural History, 77th S.C.2nd Central Park West, New York, N.Y.
15. American National Red Cross, 17th and D Streets, N.W., Washington, D.C.
16. American Occupational Therapy Assn., 175 Fifth Ave., New York, N.Y.
17. American Public Health Assn., 1790 Broadway, New York, N.Y.

18. American Seating Co., 14 East Jackson Blvd., Chicago, Ill.
19. American Social Hygiene Assn., 1790 Broadway, New York, N.Y.
20. American Society for the Control of Cancer, 1250 Sixth Ave., New York, N.Y.
21. American Society for the Hard of Hearing, 1537 Thirty-Fifth St., N.W., Washington, D.C.
22. Assn. for Family Living, 220 South State St., Chicago, Ill.
23. Assn. of American Soap and Glycerine Products, Inc., Cleanliness Bureau, 11 W. 42nd St., New York, N.Y.
24. Bauer & Black Co., Div. of the Kendall Co., 2500 S. Dearborn St., Chicago, Ill.
25. Bell & Howell Co., 30 Rockefeller Plaza, New York, N.Y.
26. Better Vision Institute, Inc., 3157 International Bldg., Rockefeller Center, New York, N.Y.
27. Bike Web Mfg. Co., 41 West 25th St., Chicago, Ill.
28. Birth Control Federation of America, Inc., 501 Madison Ave., New York, N.Y.
29. Bristol-Myers Co., 630 Fifth Ave., New York, N.Y.
30. California Fruit Growers Exchange, Box 5030, Metro. Stat., Los Angeles, Calif.
31. California State Auto Assn., Sacramento, Calif.
32. Carnation Milk Co., Oconomowoc, Wis.
33. Chicago Heart Assn., 203 N. Wabash Ave., Chicago, Ill.
34. Child Study Assn. of America, Inc., 221 W. 57th St., New York, N.Y.
35. Child Welfare League of America, Inc., 130 E. 22nd St., New York, N.Y.
36. Church & Dwight Co., 70 Pine St., New York, N.Y.
37. City of Chicago, Municipal Tuberculosis Sanitarium, 2049 Washington Blvd., Chicago, Ill.
38. Clay-Adams Co., 25 E. 26th St., Chicago, Ill.
39. College Film Center, 59 E. Van Buren, Chicago, Ill.
40. Commonwealth Fund, 41 E. 57th St., New York, N.Y.
41. Community Chest (Local).
42. Community Service Society of New York, 105 E. 22nd St., New York, N.Y.
43. Cream of Wheat Corporation, 730 Stinson Blvd., Minneapolis, Minn.
44. Denoyer-Geppert Co., 5235 Ravenswood Ave., Chicago, Ill.
45. Dental Societies (State).
46. Drug and Cosmetic Industry, New York, N.Y.
47. Dwight Posture Model, 222 Beacon St., Boston, Mass.
48. Eastman Teaching Films, Inc., 343 State St., Rochester, N.Y.
49. Education Departments (State).
50. *Educational Screen*, 64 East Lake Street, Chicago, Ill.
51. Erpi Classroom Films, Inc., 35-11 Thirty-Fifth Ave., Long Island City, N.Y.
52. Eugenics Record Office, Cold Spring Harbor, Long Island, N.Y.
53. Eugenics Society of Northern California, 720 Capital National Bank Bldg., Sacramento, Calif.
54. Evaporated Milk Assn., 307 N. Michigan Ave., Chicago, Ill.
55. Federal Council of Churches of Christ in America, 297 Fourth Ave., New York, N.Y.
56. Federal Security Agency, Washington, D.C.
    a. Office of Education.
    b. U.S. Public Health Service.
57. Florida Citrus Commission, Lakeland, Florida.
58. General Electric Co., 1285 Boston Ave., Bridgeport, Conn.
59. General Mills, Inc., 323 Fourth Ave., Minneapolis, Minn.
60. General Motors Corp., 3044 W. Grand Blvd., Detroit, Mich.
61. Good Teeth Council for Children, 17th Floor, 400 N. Michigan Ave., Chicago, Ill.
62. Hay Fever Prevention Assn., 927 Canal St., New Orleans, La.

63. Health Departments (City).
64. Health Departments (State).
65. Heinz Co., Research Dept., Pittsburgh, Pa.
66. Human Betterment Foundation, 234 E. Colorado St., Pasadena, Calif.
67. Hynson, Westcott, and Dunning, Inc., Charles & Chase St., Baltimore, Md.
68. Illinois Society for the Prevention of Blindness, 203 N. Wabash Ave., Chicago, Ill.
69. Institute of Family Relations, 607 South Hill St., Los Angeles, Calif.
70. International Cellucotton Products Co., 919 N. Michigan Ave., Chicago, Ill.
71. Interstate Narcotic Assn., 53 W. Jackson Blvd., Chicago, Ill.
72. Iodent Co., Detroit, Mich.
73. Iowa Child Welfare Research Station, University of Iowa, Iowa City, Iowa.
74. Iowa State College, Ames, Iowa.
    a. Visual Instruction Service.
    b. Extension Service.
75. Irradiated Evaporated Milk Institute, 307 N. Michigan Ave., Chicago, Ill.
76. John Hancock Mutual Life Ins. Co., Life Conservation Service, Boston, Mass.
77. Julius Rosenwald Fund, 4901 Ellis Ave., Chicago, Ill.
78. Kehoe Display Fixture Co., 541 Market St., San Francisco, Calif.
79. Kolynos Co., 130 Bristol St., New Haven, Conn.
80. *Ladies Home Journal,* Reference Library, Philadelphia, Pa.
81. Lever Brothers Co., 164 Broadway, Dept. 199, Cambridge, Mass.
82. Liberty Mutual Ins. Co., 175 Berkeley St., Boston, Mass.
83. *McCalls Magazine,* Dayton, Ohio.
84. Mass. Society for Social Hygiene, 1145 Little Bldg., Boston, Mass.
85. Maternity Center Assn., 654 Madison Ave., New York, N.Y.
86. Medical Societies (Local).
87. Medical Societies (State).
88. Metropolitan Life Ins. Co., 1 Madison Ave., New York, N.Y.
89. Milk Industry Foundation, Chrysler Building, New York, N.Y.
90. National Better Business Bureau, 405 Lexington Ave., New York, N.Y.
91. National Biscuit Co., Niagara Falls, N.Y.
92. National Board of Fire Underwriters, 85 John St., New York, N.Y.
93. National Canners Assn., 1739 H. St., N.W., Washington, D.C.
94. National Child Welfare Assn., 70 Fifth Ave., New York, N.Y.
95. National Committee for Mental Hygiene, Inc., 1790 Broadway, New York, N.Y.
96. National Conservation Bureau, Division of Assn. of Casualty & Surety Executives, 60 John St., New York, N.Y.
97. National Dairy Council, 111 N. Canal St., Chicago, Ill.
98. National Education Assn., 1201 Sixteenth St., N.W., Washington, D.C.
99. National Fire Protection Assn., 60 Batterymarch St., Boston, Mass.
100. National Foot Health Council, Rockland, Mass.
101. National Hay Fever Society, Inc., 657 Rand Tower, Minneapolis, Minn.
102. National Health Council, 1790 Broadway, New York, N.Y.
103. National Live Stock & Meat Board, Dept. of Nutrition, 407 S. Dearborn, Room 825, Chicago, Ill.
104. National Organization for Public Health Nursing, 1790 Broadway, New York, N.Y.
105. National Recreation Assn., 315 Fourth Ave., New York, N.Y.
106. National Safety Council, 20 N. Wacker Drive, Chicago, Ill.
107. National Society for Crippled Children of the United States of America, Inc., Elyria, Ohio.

108. National Society for the Prevention of Blindness, Inc., 1790 Broadway, New York, N.Y.
109. National Women's Christian Temperance Union, 1730 Chicago Ave., Evanston, Ill.
110. National Tuberculosis Assn., 1790 Broadway, New York, N.Y.
111. New York Life Ins. Co., New York, N.Y.
112. New York State Committee on Mental Hygiene, 105 E. 22nd St., New York, N.Y.
113. New York University, Center for Safety Education, 20 Washington Sq. N., New York, N.Y.
114. Nystrom, A. J. & Co., Inc., 3333 N. Elston Ave., Chicago, Ill.
115. Orthopedic Shoe Co., Portsmouth, Ohio.
116. Pepsodent Co., Educational Department, 6901 W. 65th St., Chicago, Ill.
117. Personal Products Corporation, Milltown, New Jersey.
118. Petrolagar Laboratories, Inc., 536 Lake Shore Drive, Chicago, Ill.
119. Philadelphia Child Health Society, 311 S. Juniper St., Philadelphia, Pa.
119.1 Progressive Education Assn., 221 West 59th St., New York, N. Y.
120. Prophylactic Brush Co., Florence, Mass.
121. Public Affairs Committee, Inc., 30 Rockefeller Plaza, New York, N.Y.
122. Purdue University, Extension Service, Lafayette, Ind.
123. Quaker Oats Co., Research Laboratories, 345 E. 25th St., Chicago, Ill.
124. Ralston Purina Co., Educational Service Division, Checkerboard Sq., St. Louis, Mo.
125. Scholl, Dr., 211-213 W. Schiller St., Chicago, Ill.
126. Scientific Temperance Federation, 400 Boylston St., Boston, Mass.
127. Shell Oil Co., San Francisco, Calif.
128. Simplicity Pattern Co., Inc., 200 Madison Ave., New York, N.Y.
129. Society for Visual Education, Inc., 100 East Ohio St., Chicago, Ill.
130. Standard Brands, Inc., Vitamin D Digest, 695 Madison Ave., New York, N.Y.
131. State Congress of Parents and Teachers.
132. State Universities, Extension Service.
133. Superintendent of Documents, Gov. Printing Office, Washington, D.C.
134. Takamine Corporation, 132 Front St., New York, N.Y.
135. Temperance Education Foundation, Inc., Westerville, Ohio.
136. Texas State College for Women, Extension Service, Denton, Texas.
137. Tuberculosis Societies (State).
138. Tuberculosis Societies (Local).
139. Tuberculosis Societies (County).
140. Travelers Ins. Co., 700 Main St., Hartford, Conn.
141. U. S. Dept. of Agriculture, Washington, D.C.
    a. Bureau of Home Economics.
    b. Bureau of Public Roads.
    c. Extension Service.
142. U.S. Dept. of Labor, Washington, D.C.
    a. Children's Bureau.
    b. Women's Bureau
143. U. S. Interdepartmental Committee for Coordinating Health & Welfare Activities, Washington, D.C.
144. United Fruit Co., Educ. Dept., 1 Federal St., Boston, Mass.
145. Wheat Flour Institute, 309 W. Jackson Blvd., Chicago, Ill.
146. White Laboratories, Inc., 113 North Thirteenth St., Newark, N.J.
147. Wisconsin Alumni Research Foundation, Madison, Wis.
148. *Women's Home Companion*, Service Bureau, 250 Park Ave., New York, N.Y.
149. Y.M.C.A. Motion Picture Bureau, 19 S. LaSalle St., Chicago, Ill.; 347 Madison Ave., New York, N.Y.; and San Francisco, Calif.

PART TWO

Health Instruction Materials Classified by Subject Matter and Sources for Each

(The numbers below refer to the agencies listed in Part One. The numbers 63 and 64 followed by name of city or state in parenthesis refer to the health department of that political unit.)

Alcohol and Other Narcotics—2, 71, 109, 126, 133, 135.
Adenoids—88, 133.
Amoebic Dysentery—64 (Ill.), 133.
Animal Experimentation—64 (Ill.).
Appendicitis—1, 78.
Bacteria—64 (Ill.), 88.
Birth Control—28, 56b, 133.
Blindness—9, 13, 56a, 58, 68, 108, 133.
Blood Pressure—111.
Bubonic Plague—56b.
Cancer—1, 13, 17, 20, 56b, 76, 88, 102, 121, 133.
Cardiac—(See Heart).
Charm—23, 80, 83, 97, 128, 148.
Chicken Pox—64, (Calif.).
Child Care and Education—13, 25 (films), 33, 34, 56a, 73, 88, 111, 131, 133, 142a.
  Between 2 and 6—13, 17, 76, 98.
  Child from 1 to 6—17, 131, 142a.
  Good Habits for Children—88.
  Infant Care—13, 25, 54, 104, 142a.
  Physical Condition—13, 56a.
  Prenatal Care—13, 17, 25 (film), 54, 56b, 75, 76, 88, 104.
  Safety & Health of School Child—17, 54, 56a, 76, 88, 102.
Cleanliness—23, 29, 33, 64 (Ill.), 81.
Colds—1, 17, 56b, 76, 88, 102, 111, 133.
Communicable Diseases—13, 17, 56a, 56b, 64 (Ill.), 76, 104.
  Our Common Diseases—98.
Constipation—111.
Cosmetics—13, 90.
Crippled—56a, 107.
Deafness—13, 21, 56a, 133.
  Hearing—17, 88, 102.
Diabetes—1, 13, 17, 76, 88, 102, 111.
Diet—(See Food).
Diphtheria—1, 13, 56b, 64 (Calif.), 76, 88, 106, 133.
Environment—56a, 88.
  Ventilation—17.
  Lighting—56b, 58, 108.
Endocrines—13.
Eugenics—8, 28, 52, 53, 66.
Exercise & Endurance—1, 3, 17, 24, 56b, 88, 102, 111, 133.
Eyes—1, 21, 26, 58, 68, 88, 102, 133.
  Care of the Eyes—1, 68, 88, 108.
  Diet & Eye Health—108.
  Eyes in Childhood—13, 108.
  Facts and Fallacies Concerning Crossed Eyes—68, 108.
  Home Treatment of the Eyes—108.
  Lighting the Schoolroom—56b, 58, 108.
  Ophthalmia neonatorum—68.
  Prevention of Blindness—68, 108.
  Why Wear Glasses—13, 108.
Family Relationships—12, 19, 22, 55, 69.
First Aid—1, 15, 24, 27, 35, 56b, 67, 76, 82, 88, 133.
Feet—27, 56a, 56b, 88, 100, 115, 125, 133.
Food & Nutrition—7, 13, 17, 30, 32, 42, 43, 54, 55, 56a, 57, 58, 59, 63 (Milwaukee, Wis.), 64 (Ill.), 65, 75, 76, 88, 91, 93, 97, 102, 103, 111, 119, 121, 123, 124, 129, 130, 133, 141a, 144, 145, 147.
  Chart of Food Values—30, 54, 65, 70, 103, 141a, 146.
  Diet Lists for Infants & Children—12, 32, 43, 54, 56a, 64 (Ill.), 65, 75, 103, 119, 141a.
  Family Food Supply—32, 54, 88, 141a.
  Home Pasteurization of Milk—34, 64 (Ill.).
  In Relation to Teeth—64 (Ill.), 72, 75, 119.
  Milk—1, 13, 17, 32, 54, 56a, 56b, 64 (Ill.), 75, 88, 89, 97, 130, 141a.
  Planning Meals—30, 32, 46, 54, 75, 76, 88, 111, 119, 133, 136.
  School Lunches—7, 54, 56a, 75, 93, 104, 136.
  Vitamins—12, 13, 30, 54, 65, 75, 88, 98, 103, 123, 124, 129, 133, 141a, 147.
Flies—13, 56b, 64 (Calif.).
Genetics—10.

Goitre—13, 88.
Gonorrhea—13, 17, 19, 56b, 63 (Milwaukee, Wis.), 64 (Calif.), 102, 104, 133.
Hay Fever—62, 101.
Health—76, 102, 121.
After Forty—13, 76, 111.
Conservation in Middle Age—76, 111.
National—121, 143.
Of Mother—56b, 85, 104, 111.
Of Teacher—88, 98.
Prenatal Care of Mother—13, 17, 25 (film), 54, 85, 102, 103, 142a.
Through the Ages—88.
Health Education—49, 64, 98
Biological & Scientific Material—88, 98.
Bulletins—35, 64 (Calif.).
General Information on all Subjects—13, 17, 76, 104.
Health Heroes—17, 88.
Hints—13, 30, 64 (Ill.), 109.
Measurements—98.
Method—13, 17, 56b, 147.
Outlines for Home Study—109.
Practical School Health Program—56a, 88, 109.
Programs in Schools—49, 88, 98, 104, 109, 133, 145.
Radio Script—56a, 113.
Standards—98.
Talks—56b, 86.
Teaching Plans—13, 49, 54, 56a, 88, 97, 106, 109, 113, 137, 147.
Hearing—(See Deafness).
Heart—11, 13, 33, 51, 76, 102, 104, 111, 133.
Care of "Troubled Hearts"—11, 33.
Cause of Heart Ailments—11, 33.
Diseases of Heart & Blood Vessels—111.
Facts & Fallacies—33.
Give Your Heart a Chance—88.
Prevention of Heart Disease in Childhood—11, 33.
Height-Weight Tables—13, 17, 56a, 56b, 64 (Ill.), 76, 88, 111, 133.
Heredity—10.
Home Making—12.
Home Care of the Sick—15, 63, 76.
Hookworm Disease—88.
Human Relations—119.1 (See also Social Hygiene).
Indigestion—111.
Infantile Paralysis—1, 13, 64 (Calif.), 64 (Ill.), 88, 133.
Influenza—1, 56b, 88, 133.
Information on all Questions—3, 13.
Kidney Troubles—1, 111.
Laws—64.
Insane, Feeblemindedness, Epileptics, Child Welfare, Quarantine, Burials, etc.
Lockjaw—64 (Ill.).
Malaria & Mosquitoes—56a, 56b, 64 (Calif.), 64 (Ill.), 88.
Marihuana—2, 71.
Measles—1, 13, 64 (Calif.), 64 (Ill.), 76, 78, 133.
Menstruation—70, 117.
Mental Hygiene—13, 17, 22, 40, 56a, 74, 95, 102, 113.
Mumps—64 (Calif.).
Narcotics—2, 71.
Nutrition—(See Food).
Obesity—13, 76, 88, 111.
Occupational Diseases—17, 56b, 133, 142, 143.
Occupational Therapy—16.
Physical & Medical Examinations—13, 133.
Pneumonia—1, 17, 56b, 64 (Ill.), 76, 88, 104, 133.
Posture—1, 18, 56a, 88, 97, 115, 122, 125, 133, 142a.
Physical Defects—17.
Public Health—17, 40, 56b, 64 (Calif.), 64 (Ill.), 133.
Quacks, Patent Drugs, Fads—13, 17, 90.
Rabies—13, 64 (Calif.), 64 (Ill.), 133.
Rats—56b, 133.
Recreation & Play—22, 33, 34, 73, 105.
Rest, Sleep, & Relaxation—17, 88, 102.
Respiratory Diseases—1, 56b, 111, 133.
Rheumatism—13, 88.
Safety—
Automobile—1, 5, 31, 60, 82, 88, 96, 109, 126, 127, 133, 140, 141b.
Education—15, 31, 82, 92, 96, 99, 106, 113, 126, 127.
Home—1, 76, 92.
Life Saving—15, 56a, 88.
School—56a, 96.
Vacations—1, 76, 111.
Sanitation—13, 17, 56a, 56b, 64 (Calif.), 64 (Ill.), 133.
Scarlet Fever—1, 13, 34b, 64 (Calif.), 64 (Ill.), 76, 88, 133.

School Custodian Duties—88.
Sex Education—3, 13, 17, 19, 22, 25 (films), 28, 33, 34, 55, 56a, 56b, 63 (Milwaukee, Wis), 64 (Calif.), 69, 70, 73, 74 (films), 84, 95, 102, 104, 117, 133.
Sickness Costs—88, 133.
Skin—
Poisonous Plants—1.
Troubles—21, 56b, 133.
Smallpox—13, 56b, 64 (Calif.), 64 (Ill.), 133.
Vaccination—1, 13, 56b, 64 (Calif.).
Social Hygiene—(See Family Relationships, Gonorrhea, Sex Education, Syphilis, Venereal Diseases.)
Social Work—4, 40, 55, 77.
Speech Defects—13, 56a.
Sun Bathing—64 (Ill.), 133.
Statistics—
Mortality, Morbidity, Birth—11, 13, 64 (Ill.), 133.
Syphilis—13, 17, 19, 56b, 63 (Milwaukee, Wis.), 64 (Calif.), 85, 102, 104, 121, 133.
Teeth—1, 6, 29, 36, 38, 44, 45, 56b, 59, 63 (Milwaukee, Wis.), 64 (Ill.), 72, 76, 79, 88, 102, 116, 119, 120, 133, 134.
Diet & Teeth—6, 13, 30, 64 (Ill), 103.
Healthy Teeth—1, 6, 13, 56b, 61, 76, 78, 88, 120, 133.
Oral Hygiene—6, 13, 21.
Prevention of Decay—6, 56b, 64 (Ill.), 133.
Tetanus—56b, 64 (Ill.), 133.
Tobacco—71, 109, 126.
Shall I Become a Smoker—98.
Tonsils—56b, 88, 133.
Tuberculosis—13, 17, 37, 56b, 64 (Ill.), 78, 88, 102, 104, 110, 133, 137, 138, 139.
Causes, Prevention, & Control—56a, 56b, 63 (Milwaukee, Wis.), 110.
Collapse Therapy—37.
Facts & Talking Points—1, 37, 56b.
Public Health Nursing—104.
Tularemia—64 (Ill.), 133.
Typhoid Fever—1, 13, 56a, 56b, 64 (Calif.), 64 (Ill.), 88, 133.
Underweight—13, 88.
Undulant Fever—64 (Ill.), 133.
Vision—(See Eyes).
Vitamins—(See Food).
Vaccination & Smallpox—56b, 88.
Venereal Diseases—13, 17, 19, 56b, 63, (Milwaukee, Wis.), 64 (Calif.), 102, 133.
Water—64 (Ill.), 133.
Weight Control—56b, 64 (Ill.), 103, 133.
Whooping Cough—13, 56b, 64, 88, 111, 133.

PART THREE

Health Instruction Materials Classified by Type of Material and Sources for Each

Pamphlets or Leaflets

All agencies listed have some kind of leaflet material for distribution; most of it is free. Those from Superintendent of Documents will cost a small fee, although one copy will be sent free of charge. In general, those charging a small fee for materials are:

2, 6, 8, 9, 12, 13, 19, 22, 34, 35, 40, 46, 55, 68, 69, 73, 74a, 74b, 80, 83, 84, 85, 95, 97, 98, 102, 105, 106, 109, 112, 119, 121, 128, 131, 136, 148.

Films and Slides

Usually obtainable from state public health departments and state universities.

May also be secured from the following (the name of the agency will usually indicate nature of the material; F—Free, R—Rental, S—Sell):

1-F, 6-R, 11-RS, 13-FRS, 14-R, 19-R, 20-F, 21-R, 25-RS, 39-R, 44-S, 48-S, 50-RS, 51-S, 56a-F, 56b-F, 58-F, 61-FS, 74a-R, 76-F, 82-R, 88-F, 96-F, 97-R, 104-R, 106-R, 108-F, 109-R, 110-S, 129-R, 137-F, 141c-F, 142a-F, 149-RF.

For more complete information on films the following sources are recommended:

1. An article, "Motion Pictures in Health and Physical Education," William L. Hughes and Pauline E. Stimson, RESEARCH QUARTERLY, March, 1938, p. 104.

2. Raymond L. Hopkins, Weehawken H.S., Weehawken, N.J., has collected a large amount of information in this area. Pending its publication Mr. Hopkins is glad to give information to anyone who will write to him concerning specific needs.

Posters

Most all commercial agencies have displays or posters The following agencies give, loan, or sell posters:

1, 6, 11, 13, 15, 18, 19, 21, 30, 43, 44, 54, 56a, 72, 79, 82, 85, 94, 96, 97, 103, 104, 106, 108, 109, 110, 114, 115, 117, 118, 123, 125, 137.

Exhibits

A number of state and national agencies have exhibits which they will send or loan. No. 13 is very good. Also 6, 14, 19, 61, 108, 137.

Models

6, 38 (large tooth), 38, 41 (all kinds), 47 (posture model), 78 (large set of teeth), 120 (large toothbrush).

Speakers

Usually from local public health departments, medical societies, hospitals, universities, and tuberculosis associations.

Health Plays, Songs, Drills, Stories, Games

Refer to list of publications sent free by the various agencies, particularly 5, 6, 12, 13, 54, 61, 63 (Milwaukee, Wis.), 75, 92, 97, 104, 106, 109.

General Advice or Counsel on health programs and curricula and authoritative decisions on all kinds of health questions may be obtained from 3, 13, 86, 87, 97, 98, 137.

Guidance in Required Physical Education

By George T. Stafford
Professor of Physical Education
University of Illinois

THE word "preparedness" assails us from every angle. We need more war materials; more battleships, more tanks, more ammunition must be produced immediately to save our democracy. There is also some concern about the need of man power to carry out this preparedness program. With our high standard of living has come the question of whether we have developed a race of men who lack certain essential qualities of robustness, courage, endurance, physical and emotional stamina, and general motor ability. We are definitely concerned about the quality of our man power. This concern must be extended to include not only the potential soldiers but also the workers behind the lines who are needed to supply the materials and machines which the soldiers use.

The objectives of physical education are being examined in the light of present day needs. Although we are not overlooking the social, psychological, and other outcomes of an ideal program of physical education in our quest for preparedness, we recognize that with the exception of certain psychotic cases, the army medical examination is designed to select those who are physically fit. We also recognize that physical education is of little or no direct value in preventing or correcting the common conditions for which men are rejected; namely, defective teeth, defective vision, tuberculosis, venereal diseases, hernias, and circulatory disturbances.

Our present Selective Service rejection rate is higher than the rejection rate for the first World War. Are our college students of or near draft age physically fit? Are they securing from their physical education that physical fitness which the army feels our soldiers should possess? Physical education can contribute much to preparedness.

Beginning in 1939 the physical education staff of the University of Illinois held many meetings throughout the year in attempting to determine whether our physical education program was an effective instrument for preparedness.

The University of Illinois requires each undergraduate student who enters the University as a freshman to secure credit in four physical education courses for graduation. The requirement also applies to students taking the pre-medicine, pre-law, pre-dentistry and pre-pharmacy

courses. Students entering the University with sophomore standing are required to secure credit in two courses. Students entering with junior or senior standing are exempt from securing credit in physical education. Only one semester credit can be secured in the same course. Two half-hour laboratory classes per week for one semester give one semester credit. Students with physical defects are placed in Adapted Sports (corrective physical education) where they attend three half-hour laboratory classes per week for one semester credit. All other students are allowed free choice of a wide variety of activities.

The four semester credits in physical education required by University authorities for graduation can be secured by taking and passing scheduled physical education courses and/or taking and passing proficiency examinations. In other words, a student may meet the requirement by taking and passing four courses and no proficiency examinations, or three courses and one proficiency examination, or two courses and two proficiency examinations, etc. The proficiency examination includes the same kind of examination, covers the same materials, and is scored in the same manner as the regular program examination for the same course.

CHART I

PHYSICAL EDUCATION COURSES OFFERED AT ILLINOIS

Aquatics	*Individual Sports*
Advanced Swimming	Archery
Beginning Swimming	Bait and Fly Casting [3]
Life Saving	Bowling
Water Polo and Diving	Golf
Combative	Individual Athletics
Boxing	Weight Lifting [1]
Foil Fencing	*Dual Sports*
Sabre and Epee Fencing	Badminton
Wrestling	Handball
Dance	Leisure Sports
American Square Dance [1]	Squash Racquets
Clog	Tennis
Social [2]	*Team Sports*
Tap	Group Sports
Acrobatic	Six-Man Football [1]
Advanced Circus	Soccer
Apparatus	Softball and Ice Skating [4]
Beginning Circus	Touch Football and Ice Hockey
Double Tumbling	Volleyball
Individual Tumbling	*Adapted Sports*
	(Corrective) Recommended by Health Service

[1] First offered February 1941.
[2] First offered September 1939.
[3] First offered September 1938.
[4] Grouped with team sports for administrative convenience. One-half semester is spent learning softball and one-half learning how to skate.

The above program shows a wide range of activities which could be defended as sound in the light of pupil needs, interests, and capacities for living in a *peaceful* world. But, we are not living in a peaceful world.

CHART II

UNIVERSITY OF ILLINOIS
DEPARTMENT OF PHYSICAL EDUCATION FOR MEN

SPORTS EDUCATION GUIDANCE RECORD

Recommendations:
2nd Sem. .....
.....
3rd Sem. .....
.....
4th Sem. .....
.....

Name ..... Col..... Class..... Date.....
(last) (first) (middle initial)

Age..... Height..... ft..... in. Weight.....
(Last birthday) (Without shoes) (Without clothes)

Part I. Sports Experience during **high school** years.

A. Varsity Squad	*B. Intramural, noon hour, etc.*		*C. Miscellaneous Sports (not sponsored by the school) e.g., fishing*	
1.	1.	5.	1.	5. .....
2.	2.	6.	2.	6. .....
3.	3.	7.	3.	7. .....
4.	4.	8.	4.	8. .....

Part II. P.E.M. Record: 1. Course..... Grade... 2. Course..... Grade... 3. Course..... Grade... 4. Course..... Grade...

Part III. Functional Strength Test

Events	*Raw Score 1*	*Weighted Score 1*	*R.S. 2*	*W.S. 2*	*R.S. 3*	*W.S. 3*	*R.S. 4*	*W.S. 4*
Chins	.....	.....	.....	.....	.....	.....	.....	.....
Dips	.....	.....	.....	.....	.....	.....	.....	.....
Jump	.....	.....	.....	.....	.....	.....	.....	.....
	TOTAL		TOTAL		TOTAL		TOTAL	

Part IV. Physical Ratings [Code: 1. Excellent 2. Good 3. Average 4. Poor 5. Very poor (Circle appropriate number)]

Functional Strength	1 2 3 4 5	F. S. 1 2 3 4 5	F. S. 1 2 3 4 5	F. S. 1 2 3 4 5
Posture	1 3 5	P. 1 3 5	P. 1 3 5	P. 1 3 5
Musculature	1 3 5	M. 1 3 5	M. 1 3 5	M. 1 3 5

(over)

Part V. What sports would you like to learn now?

Name .....

(over)

Part V. What sports would you like to learn now? Name .....

1. ..... 3. ..... 5. .....

2. ..... 4. ..... 6. .....

Part VI. Conferences and Recommendations

P.E.M. Courses (Check)

Aquatic

....Adv. Swim (41)
....Begin. Swim (24)
....Life Saving (42)
....Water Polo & Div. (51)

Combative

....Boxing (28)
....Foil Fencing (30)
....Sabre & Epee (47)
....Wrestling (29)

Dance

....Amer. Square (54)
....Clog (36)
....Social (52)
....Tap (35)

Acrobatic

....Adv. Circus (39)
....Apparatus (27)
....Begin. Circus (38)
....Dbl. Tumb. (26)
....Indiv. Tumb. (25)

Indiv. Sports

....Archery (46)
....Bait & Fly Cast. (50)
....Bowling (48)
....Golf (32)
....Indiv. Athletics (37)
....Weight Lifting (53)

Dual Games

....Badminton (22)
....Handball (44)
....Leisure Sports (49)
....Squash Racquets (45)
....Tennis (33)

Team Games

....Group Sports (40)
....Six-man Fb. (55)
....Soccer (31)
....Softball & Skat. (34)
....Touch Fb. & Ice Hock. (43)
....Volleyball (23)

Health Service Recommendation

....Adapted Sports (20)
....Special Sports (21)

General (Fill in)

Extracurricular Sports .....
Extra-P.E.M. Courses .....
Keep Fit Club .....
Health Habits .....
Health Examination Recheck .....
Social Activities .....
Miscellaneous .....
.....

The majority of our activities could not be called vigorous. It is true that bowling may be considered vigorous enough and quite satisfactory for some individuals. However, bowling as compared with wrestling is obviously less vigorous; bowling is less vigorous than apparatus stunts.

Many of our instructors were of the opinion that students who had selected the less vigorous activities offered in our program were lacking in robustness, endurance, and general motor ability. Students in social dancing were often the asthenic type who, in the opinion of many instructors, might better have chosen the more vigorous activities. Were the students, with their privilege of free choice of activities, avoiding those courses which might give them organic vigor, stronger muscles, and greater motor ability?

In order to give the student some data for self-analysis to guide him in his choice of activities which would best meet his total needs, it was felt necessary to secure more information as to his past experience in sport activities, his present interest in sports, and some data showing his functional strength rating. These data were also necessary to assist the instructors in their counselling of the students.

The European situation in the fall of 1940 seemed to provide propitious motivation for initiating the students to the idea of physical preparedness. Each instructor explained to his students the need for physical fitness and our hopes that through the physical education program greater physical fitness could be secured. They were informed that they would be given a simple test to determine their present functional strength and that other data would be taken in an attempt to guide them in their selection of activities which would best meet their needs.

A careful study had been made of the many strength, motor ability, and muscular efficiency tests for the purpose of securing a test which would fill the following requirements:

Simplicity of administration, reliability, validity, objectivity, and arouse student interest in his general physical condition.

Through the courtesy of Dr. Leonard A. Larson, his combination of chinning, dipping, and vertical jump test [1] was used for what we have chosen to term the "Functional Strength Test." This test was given during the first semester (November, 1940) to 3,262 male students as a part of the Sports Education Guidance Program.

PURPOSE OF THE STUDY

To formulate a simple set of standards for use in classifying students on the basis of their functional strength.

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[1] Larson, L. A., A Factor and Validity Analysis of Strength Variables and Tests with a Test Combination of Chinning, Dipping, and Vertical Jump: RESEARCH QUARTERLY XI (December, 1940) pp. 82-96.

Note: This test has a correlation of .82 with the all-round motor ability test which is assumed to be highly valid in measuring total motor ability.

To secure information which could be used to motivate the student in his selection of those activities which might improve his functional strength.

LIMITATIONS

Obviously the use of a larger battery of items in the test would raise the validity of the test. Considering the purpose of the test it was decided that the slight increase in validity which could be secured by the addition of more items did not warrant the time necessary to administer the larger test. The writer is cognizant of the criticism that many physical education programs are conducted with little or no testing to determine either the individual's needs or the effectiveness of the program. He also realizes that in some instances the time given to testing makes it impossible to allow sufficient time for teaching the necessary knowledges, skills, and appreciations which should be considered in the total learning situation. For the fullest expression of the total personality, personal and social relationships and other factors must be given time commensurate with their importance. Therefore, it was decided to spend not more than one class period in administering the test. The test is recognized as being limited to an analysis of strength variables as one index of motor ability—it is not claimed as a method of determining total strength.

PROCEDURE

A meeting of all instructors was held prior to administering the test at which time all procedures * were explained, demonstrated, and each instructor demonstrated all procedures. Classes were scheduled to meet at four different testing stations. Regular street clothes were worn. By not having the students change clothes, classes were scheduled to meet at the beginning of the hour and to remain until ten minutes to the next hour. Each instructor had one or more assistants.

Upon arrival at test stations each class was divided into four groups.

Group 1 was weighed and measured and filled out their Sports Education Guidance Record card through Part I (see Chart II). (Part II was filled out by sophomores only.)

Group 2 was testing on chinning.

Group 3 was tested on jumping.

Group 4 was tested on dipping.

All test figures and raw scores were recorded by the instructor or his assistants.

When all groups had completed their particular activities, Group 1 went to the chinning station, group 2 to the jumping station, group 3 to the dipping station, and group 4 to the weighing and measuring station. This rotation was repeated until all groups had completed their activities.

* See appendix.

At the end of each day each instructor recorded the weighted score, computed totals, and rated each student on posture and musculature. This rating was subjective and intended only to pick out gross deviations. The original card allowed for only two ratings: satisfactory and

TABLE I
DISTRIBUTION OF FUNCTIONAL STRENGTH TEST SCORES

	No.	Per Cent
Excellent	230	7.0
Good	910	27.8
Average	1315	40.3
Poor	640	19.6
Very Poor	167	5.1

Larson's Findings for Springfield College Men

Excellent	6.45	Poor	24.17
Good	24.17	Very poor	6.45
Average	38.30		

TABLE II
FUNCTIONAL STRENGTH SCORES FOR ALL ACTIVITIES

	Excellent		Good		Average		Poor		Very Poor	
Course	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.
(All students)	7.00	230	27.8	910	40.3	1315	19.6	640	5.1	167
Advanced Swimming	4.56	9	30.96	61	42.13	83	16.75	33	5.58	11
Apparatus	21.56	22	44.11	45	28.43	29	6.86	7		0
Archery		0	17.85	10	46.42	26	23.21	13	12.5	7
Badminton	5.0	6	23.33	28	40.00	48	24.16	29	7.5	9
Bait and Fly Casting	7.66	3	15.38	6	33.33	13	23.07	9	20.51	8
Beginning Swimming	4.79	7	17.80	26	43.14	64	30.13	44	3.42	5
Bowling	2.97	5	17.26	29	42.85	72	29.16	49	7.73	13
Boxing	11.42	8	31.42	22	44.28	31	10.0	7	2.85	2
Circus	9.30	8	24.41	21	39.53	34	17.44	15	9.30	8
Clog Dancing		0	23.33	7	40.00	12	30.00	9	6.66	2
Foil Fencing	5.30	7	21.21	28	35.60	47	26.51	35	11.36	15
Golf	2.10	2	29.46	28	41.05	39	18.94	18	8.42	8
Group Sports	8.75	7	32.50	26	38.75	31	16.25	13	3.75	3
Handball	1.88	3	26.41	42	44.65	71	22.01	35	5.03	8
Individual Athletics	19.16	23	38.33	46	29.16	35	13.33	16	0	0
Individual Tumbling	13.46	14	45.57	47	26.92	28	13.46	14	.96	1
Leisure Sports	2.81	2	25.35	18	46.47	33	18.31	13	7.04	5
Life Saving	21.62	8	21.62	8	40.54	15	16.21	6		0
Sabre, Epee Fencing	33.33	2		0	16.66	1	50.00	3		0
Soccer	2.10	4	24.21	46	44.73	85	24.21	46	4.73	9
Social Dancing	5.88	5	31.76	27	44.7	38	14.11	12	3.52	3
Softball	9.05	25	30.47	86	40.21	112	17.02	47	3.27	9
Squash	3.84	2	11.53	6	42.3	22	38.46	20	3.84	2
Tap Dancing	3.12	5	24.37	39	47.50	76	20.62	33	4.37	7
Tennis	5.00	8	24.37	39	41.87	67	23.12	37	5.62	9
Touch Football, Ice Hockey	6.52	3	28.26	13	47.82	22	15.21	7	2.17	1
Volleyball	4.00	7	30.85	54	44.00	77	14.85	26	6.28	11
Water Polo, Diving	12.82	5	38.46	15	33.33	13	10.26	4	5.12	2
Wrestling	11.28	29	35.01	90	35.79	92	14.78	38	3.11	8

unsatisfactory. The tests now used will record satisfactory, average, and unsatisfactory posture and musculature.

The results of the Functional Strength Test are given in Table I.

As many instructors were of the opinion that students of the asthenic type tended to select the less vigorous activities and the more robust student selected the more vigorous activities, Table II is offered to show the actual functional strength distribution for each sport activity.

TABLE III

PERCENTAGE SCORES IN LESS VIGOROUS ACTIVITIES

	Excellent	Good	Average	Poor	Very poor	Totals
(For all students)	7.0	27.8	40.3	19.6	5.1	3,262
Archery	0	17.85	46.42	23.21	12.5	56
Bait and Fly Casting	7.66	15.38	33.33	23.07	20.51	39
Bowling	2.97	17.26	42.85	29.16	7.73	168
Clog Dancing	0	23.33	40.00	30.00	6.66	30
Golf	2.10	29.46	41.05	18.94	8.42	95
Leisure Sports	2.81	25.35	46.47	18.31	7.04	71
Social Dancing	5.88	31.76	44.7	14.11	3.52	85

TABLE IV

PERCENTAGE SCORES IN MORE VIGOROUS ACTIVITIES

	Excellent	Good	Average	Poor	Very poor	Totals
(For all students)	7.0	27.8	40.3	19.6	5.1	3,262
Apparatus Stunts	21.56	44.11	28.43	6.86	0	102
Boxing	11.42	31.42	44.28	10.0	2.85	70
Individual Athletics	19.16	38.33	29.16	13.33	0	120
Individual Tumbling	13.46	45.57	26.92	13.46	0.96	104
Life Saving	21.62	21.62	40.54	16.21	0	37
Wrestling	11.28	35.01	35.79	14.78	3.11	257

In order to secure some data as to the musculature and posture of the students, each instructor rated his students by inspection into two groups.

After all data had been secured and tabulations had been completed, instructors held conferences with the students who had been rated poor and very poor in the Functional Strength Test. Their sports experience during high school years were discussed. They were encouraged to tell why they would like to learn how to participate in certain sports which they had noted under Part V of their record card. Questions were raised as to their health habits, social life, progress in school work, etc. An attempt was made to have the student understand the significance of his functional strength score and each student was encouraged to select an activity or activities which he felt would ameliorate his deficiency. Many students wanted to avoid the more robust type of activities because they felt they would be hopelessly outclassed, etc. At the

TABLE V

COMPARISON OF STRENGTH AVERAGES OF VIGOROUS ACTIVITY GROUPS WITH THOSE OF LESS VIGOROUS ACTIVITY GROUPS

Average strength of less vigorous activities		Average Strength of Vigorous Activity Groups																			
		Individual Athletics (Average 318.10 ± 5.04)																			
				Individual Tumbling (Average 306.30 ± 5.22)																	
						Life Saving (Average 306.30 ± 8.19)															
								Wrestling (Average 305.20 ± 3.52)													
										Apparatus (Average 304.75 ± 5.48)											
												Boxing (Average 299.8 ± 5.45)									
														Water Polo (Average 298.70 ± 5.45)							
																Group Sports (Av. 295.1 ± 6.61)					
Activity	Strength average	Diff.	C.R.	Diff.	C.R.	Diff.	C.R.	Diff.	C.R.	Diff.	C.R.	Diff.	C.R.	Diff.	C.R.	Diff.	C. R.	Average C.R.			
Archery	253.50	64.6	7.71	58.8	6.49	52.8	4.78	52.2	6.37	51.3	5.56	46.3	5.05	45.2	4.22	42.1	4.23	5.55			
Fly Casting	255.50	62.6	4.37	56.8	3.95	50.8	3.24	50.2	3.62	49.3	3.41	44.3	3.07	43.2	2.79	39.6	2.65	3.39			
Clog Dancing	260.95	57.2	5.95	51.4	5.29	45.4	3.92	44.8	5.01	43.8	4.45	38.9	3.94	37.8	3.35	34.2	3.24	4.39			
Bowling	265.60	52.5	7.92	46.7	6.96	40.7	4.41	40.1	7.20	39.15	5.67	34.2	4.94	33.1	3.77	29.5	3.75	5.58			
Badminton	267.00	51.0	6.09	45.3	5.34	39.3	3.71	38.7	5.13	37.8	4.36	32.8	3.81	31.7	3.09	28.1	2.98	4.31			
Foil Fencing	267.80	50.3	6.62	44.5	5.69	38.5	3.83	37.9	5.53	36.9	4.62	32.0	4.03	30.9	3.19	27.3	3.09	4.57			
Leisure Sports	271.00	47.1	5.71	41.3	4.93	35.3	3.37	34.7	4.64	33.8	3.95	28.8	3.37	27.7	2.73	24.1	2.58	3.91			
Begin. Swim.	271.30	28.5	4.25	41.0	5.98	35.0	3.75	34.4	6.07	33.5	4.72	28.5	4.03	27.4	3.06	23.8	3.15	4.37			
Squash	273.30	44.8	5.56	39.0	4.30	33.0	3.19	32.4	4.49	31.5	3.76	26.5	3.19	25.4	2.54	21.8	2.37	3.68			
Soccer	274.00	44.1	7.11	38.3	6.06	32.3	3.61	31.7	6.34	30.8	4.69	25.8	3.98	24.7	2.89	21.1	2.79	4.76			
Handball	274.00	44.1	6.65	38.3	5.65	32.3	3.50	31.7	5.69	30.8	4.45	25.8	3.72	24.7	2.78	21.1	2.68	4.39			
Golf	275.80	42.3	5.46	36.5	4.63	30.5	3.02	29.9	4.31	28.9	3.14	24.0	2.98	22.9	2.35	19.3	2.17	3.51			
Tap Dancing	277.90	40.2	6.06	34.4	5.07	28.4	3.06	27.8	4.99	26.9	3.87	21.9	3.16	20.8	2.34	17.2	2.18	3.90			
Tennis	282.10	36.0	6.32	30.2	5.14	24.2	2.81	23.6	5.33	22.7	3.71	17.7	2.91	16.6	2.03	13.0	1.82	3.76			
Volleyball	284.30	33.8	5.16	28.0	4.18	22.0	2.38	21.4	3.91	20.5	2.95	15.5	2.24	14.4	1.63	10.8	1.37	2.98			
Adv. Swim.	285.10	33.0	5.35	27.2	4.41	21.2	2.37	20.6	4.12	19.65	3.00	14.7	2.24	13.6	1.59	10.0	1.25	3.03			
Social Dancing	291.30	26.8	4.23	21.0	3.23	15.0	1.66	14.4	2.77	13.5	2.00	8.5	1.30	7.4	.85	3.8	.49	2.07			
Softball	291.70	26.4	4.40	20.6	3.34	14.6	1.65	14.0	2.92	13.1	2.04	8.1	1.27	7.0	.83	3.4	.45	2.11			
Touch Football	294.25	23.9	3.20	18.1	2.29	12.1	1.19	11.5	1.67	10.50	1.42	5.6	.69	4.5	.46	.9	.096	1.37			
Average C. R.			5.69		4.91		3.10		4.74		3.78		3.15		2.45		2.28				

TABLE VI

Less Vigorous Activities in Ascending Order of Vigor	Average C.R.	Vigorous Activities in Descending Order of Vigor	Average C.R.
Bowling	5.58—Least	Individual Athletics	5.69—Most
Archery	5.55	Individual Tumbling	4.91
Soccer	4.76	Wrestling	4.74
Foil Fencing	4.57	Apparatus	3.78
Clog Dancing	4.39	Boxing	3.15
Handball	4.39	Life Saving	3.10
Beginning Swimming	4.37	Water Polo	2.45
Badminton	4.31	Group Sports	2.28—Least
Leisure Sports	3.91		
Tap Dancing	3.90		
Tennis	3.76		
Squash	3.68		
Golf	3.51		
Fly Casting	3.39		
Advanced Swimming	3.03		
Volleyball	2.98		
Softball	2.11		
Social Dancing	2.07		
Touch Football	1.37—Most		

end of the conference each student received a slip on which was written a specific area of physical education in which he should enroll the following semester. Students who showed good arm strength but were weak in jumping might be given a recommendation for team games, or dancing (tap, clog, or American square dance). Those with weak arms were given a recommendation for combative activities, weight lifting, etc.

In addition to recommending students for specific areas which might improve their conditions, all students rating poor and very poor in the Functional Strength Test, and who were enrolled in the milder activities at the time the test was given, were assigned to the "Keep Fit Club" *

TABLE VII

MUSCULATURE RATINGS

		Per cent
Satisfactory (excellent to average, or firm)	2,798	86.7
Unsatisfactory (poor to very poor, or flabby)	464	14.2

TABLE VIII

POSTURE RATING

		Per cent
Satisfactory	2,937	90.0
Unsatisfactory	325	10.0

* Keep Fit Club. Non-credit. Meets five days per week from 4:00 to 6:00 p.m. In this club activities of a development type are prescribed as needed. Emphasis is given to weight lifting, calisthenics, and other activities common to most college gymnasia.

for participation at least one hour per week for the remainder of the first semester. Those who were enrolled in the more vigorous courses were also encouraged to join the Keep Fit Club if their present functional strength rating was poor or very poor.

CONCLUSIONS

1. The Larson "Chinning, Dipping, and Vertical Jump" test provides a simple instrument for classifying students on the basis of their functional strength.

2. Approximately 75 per cent of the students scored "average," "good," or "excellent" on the functional strength test. Therefore, those in the "poor" and "very poor" fall in the lower 25 per cent. Psychologically there is no premium on being in this group. They may be motivated to improve their condition and rise, at least to the average.

3. The figures do not bear out the instructors' expressed opinions that students in all the less vigorous activities were lacking in functional strength as compared with the average student. Students taking social dancing compared favorably with the average students.

4. For courses rated as vigorous there is definite evidence of a higher degree of functional strength possessed by these students than for the average. For counselling purposes this information is useful in pointing out to students who desire to take the more vigorous activities their need for good functional strength if they hope to gain the most from the more vigorous physical education activities.

5. In the light of the present emphasis on preparedness we feel that those who fall in the poor and very poor class in the functional strength test should be urged to consider the possibility of working to improve on those activities which lowered their score. Students who were unable to chin once might be motivated to exert more effort to improve their arm strength. It could be pointed out that although this arm strength might not be necessary in earning one's living, the lack of it might be indicative of a general weakness of which the individual was not inwardly proud.

6. Guidance in physical education needs more serious consideration than it has received in the past. The single factor of functional strength is but one of the many factors which must be considered in guiding the total personality. Other factors to be considered in guidance are:

A. Academic status
B. Health examination record
C. Health habits
D. Social integration
E. Personality traits
F. Vocational choice
G. Miscellaneous information pertaining to recent illnesses, acci-

dents, operations, any abnormalities of body build, gait, facial blemishes, etc.

7. Anyone attempting guidance should at least be familiar with the works of:

Bell, "Theory and Practice in Student Counselling with Special Reference to Adjustment Inventory"

Bernreuter, "Personality Inventory"

Blanchard, "Behavior Frequency"

Cowell (Numerous studies on personality)

Link, "A Test of Four Personality Traits of Adolescents"

Washburn, "Test for Social Adjustment"

Wetzel, "Physical Fitness in Terms of Physique, Development, and Basal Metabolism with a Guide to Individual Progress from Infancy to Maturity."

8. The student's desire to participate in a certain activity should be given more consideration even though he does not score high in his functional strength test. If an individual has a definite interest in an activity can the instructor always be sure that he, the instructor, knows what is best for the student's total needs? Perhaps the student who wants social dancing is seeking better social integration and may, in his case, be better adjusted through social dancing than by participating in volleyball where his every poor act penalizes not only him but the other members of his team as well. Why not provide the student with opportunities to secure as much happiness as possible. The outstanding characteristic of a healthy person is that he is happy. With this hysteria for preparedness we should not underestimate the fact that we are dealing with a total personality and too much worshipping at the shrine of the big muscle cult may not give us the contribution to the preparedness of the total personality which we are seeking.

APPENDIX

Procedure for the Administration of the Functional Strength Test

General Suggestions:

1. If the instructor gives the test *without the assistance of* a fellow instructor, *or a student teacher,* he should keep his entire class together, and give each student the *chinning test,* then the *vertical jump,* and finally the *dipping.*

2. If he has the *assistance of a student teacher,* he may *divide* his group, letting *this assistant score* the *chinning* while he takes the vertical jump himself. In almost all classes, there will be *at least one student teacher and probably one additional instructor* to assist. The group should then be divided into three equal divisions. In any case, the groups should be kept together, i.e. those engaging in *chinning* should *remain* at the bar, *IN LINE,* until told to move elsewhere, and those engaging in the *vertical jump* and the *dips,* should also remain there until requested to move to the next test. In *no case* should the students be permitted to surround the individual being tested. Avoid informality of action and speech, and keep them under formal control to assist in running off the test smoothly.

3. There must be a *minimum of ten minutes rest between chinning and dip-*

ping. Check the time when you start with the first student, and when you finish with the last one in a particular group. If the same order is maintained, you should find at least ten minutes elapsing. Count chins and dips *silently*.

4. *Jumping* and *catching* the *horizontal bar* is *merely* the *beginning* of this part of the test, and *does not count* as one chin. Be sure to have chalk available. Occasionally have the bar wiped.

5. Appoint a competent student to clean off the chalk marks *after* each subject has *completed* the *vertical* jump.

6. Be sure the initial REACH in the *vertical jump* is secured with *both feet* (and *heels*) *flat on the floor*.

7. *Caution* students not to stand too close to bottom of board, to avoid striking shoulder when jumping.

8. *Jumping to position* on the *parallel bars* is *counted* as ONE DIP in recording the number of dips the subject can execute. Be sure to have chalk available. Occasionally have the bars wiped.

9. To avoid errors, the person in charge of each part of the test should record the raw score on each student's card in pencil. Write *distinctly*.

Specific suggestions:

1. *Chinning*: The subject's feet should not touch the floor when he is in a lowered position. He may use either the forward or the reverse grip. To begin, the *subject hangs from the bar* with *arms fully extended*, then *pulls himself up until his chin is over the bar* (but not resting on it), then lowers himself until his *arms* are *straight again*. Each time he completes this movement, score one point. The subject is *not permitted to kick, swing*, or *rest*. *Partial* or *faulty chins* are *not counted*, but the participant may continue, and proper chins *will* be counted. The subject may chin at any rate of speed, but the examiner should *stop any swinging* or *movement* of the *legs* (which might aid in doing the exercise) by extending his arm and stopping the motion.

2. *Vertical jump*: The subject places chalk dust on his finger tips *just before* his turn. Then he *stands* as *close to the wall* (or beam) as possible, and reaches up with *both arms outstretched*, making the *highest* possible *marks with* his *finger tips*. To get full height press students back toward the board. BOTH FEET (and HEELS) must be *flat on the floor*. This height is recorded while the subject places more dust on the middle finger of one hand. He then *stands sideways*, with the *right OR left arm* close to the wall, *and jumps, striking* the palm and *fingers* of the *inside hand against* the *board*. The instructor calls out the height of this mark, and it is recorded. No attempt should be made to compute the actual height jumped until after the entire test (chinning, vertical jump, and dips) has been given. The subtraction and translation into weighted scores may be done *after* the *students have been dismissed*.

3. *Dips*: The *subject jumps to a front rest position* at the end of the parallel bars with *arms fully extended*. This counts ONE DIP. From this position the subject *lowers* his *body to a right angle arm bend position*, and *pushes up* to the *first position*. Each time the subject does this successfully it counts ONE DIP. The subject is *not permitted to rest* in any position, *swing*, or *kick*. *Partial or faulty dips are not counted*, but the participant *may continue*. The subject may dip at any rate of speed, but the examiner should stop any *swinging or movement* of the *legs* (which might aid in doing the exercise) by extending his arm and stopping such motion.

Scoring: The steps in computing the score are:

1. Change raw score into "weighted score."
   Chinning, Table I, Column 1, page 3.
   Jump, Table I, Column 2, page 3.
   Dips, Table I, Column 3, page 3.
2. Add the "weighted scores" for the "total score."

TABLE IX

SCORING TABLE FOR FUNCTIONAL ABILITY TEST

Chinning		Vertical Jump		Dips	
Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
30	276	26.0	227	30	109
29	267	25.5	221	29	106
28	259	25.0	213	28	104
27	252	24.5	208	27	101
26	244	24.0	202	26	98
25	235	23.5	196	25	95
24	227	23.0	188	24	92
23	220	22.5	183	23	89
22	212	22.0	177	22	87
21	204	21.5	172	21	84
20	197	21.0	166	20	81
19	189	20.5	158	19	78
18	180	20.0	152	18	75
17	174	19.5	147	17	72
16	165	19.0	141	16	70
15	157	18.5	136	15	67
14	148	18.0	127	14	64
13	142	17.5	122	13	61
12	134	17.0	116	12	58
11	125	16.5	109	11	55
10	119	16.0	102	10	52
9	110	15.5	97	9	50
8	102	15.0	91	8	47
7	95	14.5	85	7	44
6	87	14.0	77	6	41
5	78	13.5	72	5	38
4	72	13.0	66	4	35
3	64	12.5	60	3	33
2	55	12.0	54	2	30
1	47	11.5	47	1	27
		11.0	41		
		10.5	35		
		10.0	27		
		9.5	22		
		9.0	16		
		8.5	13		
		8.0	5		
Mean = 8.5		Mean = 17.0 (Approximately)		Mean = 9+	

Classification Scale

Percentile Values		Score Values and Classification Based on Sigma Units *	
		368–up	Excellent
90	356		
80	329	309–367	Good
70	309		
60	292		
50	277		
40	264	249–308	Average
30	250		
20	232		
10	200	190–248	Poor
		189–down	Very Poor

* MacCurdy, H. L. *A Test for Measuring the Physical Capacity of Secondary School Boys* (Yonkers, N.Y., 1933) p. 53.

3. Use the following temporary classification scale, and *record single digit on grade chart,* but NOT ON CARD.

368 — up = "1" (excellent)
307 — 367 = "2" (good)
249 — 308 = "3" (average)
189 — 248 = "4" (poor)
189 — down = "5" (very poor)

The distribution of the "weighted scores" will later be used to determine "Illinois norms" for a more accurate classification of the subjects.

BOOK REVIEWS

SOCIAL AND BIOLOGICAL ASPECTS OF MENTAL DISEASE. Benjamin Malzber, Ph.D. Utica, N.Y.: State Hospital Press. $2.50.

Physical health as measured by death rates has improved during recent years despite unfavorable economic conditions. On the other hand, Dr. Malzberg maintains that if present trends continue, mental health will soon become our foremost health problem. His book is a highly creditable attempt to state the problem of mental health as accurately as possible, not only quantitatively but qualitatively. The source of his data is the highly complete and standardized statistical information compiled by the New York State Department of Mental Hygiene. The text is thoroughly fortified with significant tables, computations, and explanations. A convenient summary follows most chapters and the final chapter represents a resume of the entire book.

Since records such as the author used are notable for their scarcity in most states, we can reasonably conclude that his book deals with one of the best available samples of our mental health situation. One need only mention a few of the chapters to indicate its usefulness; the Increase of Mental Disease; the Relation of Mental Disease to Age; Sex, Environment, and Marriage; Nativity and Race; Expectation of Life; and the Treatment of Dementia Praecox by Insulin Shock.

The upward trend in mental diseases seems primarily due to increased rates among the young (psychoses with epidemic encephalitis and dementia praecox) and the old (psychoses with cerebral arteriosclerosis). Males in general have higher rates of first admission than females, especially with psychoses involving cerebral arteriosclerosis and dementia praecox. The conclusions for general paresis and alcoholic psychoses are clearly a reflection of social attitudes toward promiscuous sex relations and excessive drinking. Rates of admission are lowest in childhood and rise steadily to a maximum in old age, the increase being especially rapid after 60. They are clearly lowest among *rural* populations! In cities, the struggle for existence is intense and mental disease is often but evidence of failure to conquer a very complex environment. This is further reflected in the rates for mental disease among the foreign born. When age and urban-rural rates are both held constant, there is found to be no significance in rates of mental disease between the native and foreign born. The higher rate among negroes is traceable to mental disease resulting from syphilis and alcoholism but these are held to be largely the consequence of the deleterious social environment of the negro. Additional instability in this race follows from their migratory tendencies.

In the white population, differences between national and subracial groups are held to be the result of environmental factors. For example, the children of foreign born Italians have lower rates of mental disease than their parents, but higher than native whites of native parentage. This is what one would expect in an environmental hypothesis. While seemingly inclined toward environmental considerations in this study, Dr. Malzberg does not deny that there are biological factors associated with mental disease, as seen in their genetic aspects. However, he maintains these operate through families and not through races, for every race has family stocks in which mental disease appears with disproportionate fre-

quency. He also noted the influence of social factors on mental disease in recent years; with the coming of the depression the percentage of cases in which the loss of employment or financial loss was considered a causative factor, increased. With a return of prosperity in 1937 there was a corresponding decrease.

Despite the foregoing, Dr. Malzberg is far from being pessimistic with regard to the future. Paresis, for example was fatal twenty years ago but through the improvement of treatment has steadily declined in death rate, while the degree of improvement has gone higher. Insulin shock therapy has brought about remarkable rates and recovery and improvement in dementia praecox. Alcoholic and syphilitic mental diseases can be controlled if well known principles of prevention are applied and there is always the possibility of medical progress in the control of arteriosclerotic diseases. In brief, medical knowledge and enlightened social policies hold out the possibility of controlling mental health.

N. M. GRIER, Ph.D.
Chairman, Lebanon County Mental Health Clinic, Lebanon, Pa.

HORSEMANSHIP AND HORSEMASTERSHIP. Fort Riley. (Fort Riley, Kansas, 1941.) $1.00. (Five parts published in three volumes.)

Fort Riley has just published the 1941 edition of their excellent textbook. This edition has many improvements over the previous copies and is well worth the low price of one dollar even for those who have an earlier copy.

The three volumes cover many phases of horsemanship, including learning to ride, jumping, training horses; animal management and horseshoeing; the organization of horse shows, race meetings, and hunter trials. The chief drawback of the book is the indexing, placed at the end of each part and so arranged as to make it difficult to find information. Also some of the explanations are extremely lengthy, involved, and technical. But the book is detailed and unbiased, and all statements are accurate, based on the findings at the Cavalry School.

Volume I, 251 pages. Part One—"Education of the Rider" (170 pages). This covers the position required both for slow and fast equitation, and over jumps, application of the aids and suppling exercises, riding hall movements and customs, use and fittings of saddles and bits, the mental faculties of the horse, methods of instruction. This section of the book is useful as a reference for both student and instructor.

Part Two, "Education of the Horse" (81 pages). This part, besides covering the breaking and training of the horse to saddle and to jump loose, on a lunge and when ridden, also offers suggestions for teaching the student these advanced phases of equitation. New diagrams and illustrations, with replacing of text, increase the value of the 1941 edition of Volume I.

Volume II, Part Three A, "Animal Management" (revised, January 1937). Under this heading is included: anatomy and physiology of the horse; colors, measurement, age, conformation, and judging; examining for soundness; feeds and feeding; diseases, injuries, and first-aid treatment; gaits of horses; outline of breeds; the transportation of horses. This material is given concisely and is suitable for reference by those who are in charge of horses, and for instructors and students interested in studying the history, care, and handling of horses.

Volume II, Part Four, "Horseshoeing" (20 pages, diagrams). This part explains the anatomy of the foot and the principles of shoeing—a useful aid to appreciating the importance of having a good blacksmith regularly.

Volume III, Part Five, "Horse Shows, Race Meetings, Hunter Trials" (78 pages). Much useful material is offered for the committee planning to run any of the above events, which if followed would lead to better organization than is usually followed in the smaller events. This material would also be of value to the instructor who is planning a horse

show for students at the end of the school or camp season. The designs of the jumps and courses are also suitable for the schooling field.

Horsemanship and Horsemastership, because of its completeness, accuracy, unbiased statements, and low price, makes an excellent text and reference book for the owner and rider, the student and the instructor.

PHYLLIS LININGTON
Miss Linington's Stable
Milton, Massachusetts

TRAIL OF AN ARTIST-NATURALIST. Ernest Thompson Seton. (New York: Charles Scribner's Sons, 1940) 412 pages, $3.75.

By lineage Seton is Scotch, of the Cameron clan. His forebears, because of their Jacobitish activities, crossed the border and under the assumed name of Thompson settled in northern England, where they attained success in connection with the Merchant Marine. A turn of fortune dissipated much of their wealth, so in 1866 when Ernest was six years old, his parents with their ten children migrated to Canada and settled on a partially cleared farm near Lindsay, Ont. Mr. Seton's deep interest in nature and insatiable curiosity were stimulated by opportunity, and he developed an unusual knowledge of and sympathy for wild life and Indians.

His father, a civil engineer and expert accountant, was not adapted to pioneer life, so the family moved to Toronto, where during his school days Ernest developed his native artistic ability and took every opportunity of associating with fishermen, hunters, and outdoor people, and began writing his first nature stories. At the age of nineteen, having completed an ordinary school education in Canada, he entered the Royal Academy in London for training in painting. By unusual persistence he secured not only permission to use the British Museum (available only to adults) but was granted a life membership. His life in London, fighting poverty, his return to Canada and location in Manitoba, "The Land of My Dreams," are narrated in detail. His observations were thorough; measuring, counting, sketching, and otherwise recording. He began his "Journals," which eventually attained "fifty fat leather-clad volumes, many of them over fat."

In 1883 he ventured to New York City, a penniless stranger, but some of his paintings attracted attention, especially of C. Hart Merriam, who after watching Seton at work ordered fifty drawings. In the following spring he returned to Manitoba where his brother was homesteading and began a period of which as a chapter heading he describes as "Freedom and Joy." This chapter and those following are crowded with incidents, discoveries, Indian contacts, and scientific observations. He became the official naturalist for the Province of Manitoba, and, besides his official reports, wrote many nature stories which were the delight of thousands of readers. His scientific text *Birds of Manitoba* was begun at this time and this, together with *Lives of Game Animals* (8 volumes) are representative of his formal work.

New York was visited again in 1885 and a sample drawing attracted the attention of the art director of the *Century Magazine,* resulting in an order for one thousand additional drawings at $5.00 each to illustrate the Century dictionary.

The next year the west called him back to Manitoba where he continued his previous work there. After several years he realized the need of further study, so went abroad, this time to Paris, where his triumphs and disappointments are faithfully set forth. After this period a sojourn in the southwestern states, then a return to New York to begin a successful career as the originator of the modern school of animal stories. Several of these became best sellers because of their intrinsic merit and partly because of his unusual success as a lecturer, in which capacity he mentioned his own publications. Under the management of Major Pond he for several years filled a contract of $600 per week for twenty weeks each year.

An interesting sidelight is thrown on the controversy with John Burroughs, who charged that Seton and his followers, especially J. W. Long, were "nature fakers."

By 1900 Seton was in a position to realize his dream of a nature retreat where he could experiment on conservation and restocking with every kind of wild life. But the "natives" living near his reservation in Connecticut regarded him as an intruder. The outcome, as a measure of self-protection, was the organization of his Woodcraft Indians, so well known for its success in development of boy groups through living the Indian life and its ideals.

By 1930 he sold his eastern holdings and bought twenty-five hundred acres near Santa Fe, New Mexico, where he established his School of Indian Wisdom.

Seton is a man of exceptional industry, unusually keen observation, an artist not only in recording and interpreting with brush and canvas, but also on the lecture platform and the printed page. Kipling, Charles G. D. Roberts, Clarence Hawkes, and others have acknowledged their indebtedness to his influence. Thousands of readers have been delighted and informed by hundreds of his books and stories, while science has been advanced and humanized by his persistence and imagination.

This autobiography is a credit to the author and publisher alike. It is generously illustrated with reproductions of his sketches and paintings and has an unusually detailed index. It is deserving of reading and study by all interested in the out-of-doors.

G. B. AFFLECK
Springfield, Mass.

ERRATA

Please note the following errors which crept into the manuscript of the article in the March, 1941, issue of the RESEARCH QUARTERLY on "The Best Method of Artificial Respiration" by Peter V. Karpovich.

In Table I, which appears on page 52 of this issue, the heading *"On Cadavers"* in the stub column should be dropped to a position directly over "Bruns." Then the findings of Bruns as shown in the line opposite his name should be changed as follows: for the Schafer method, 0.050; for the Silvester method, 0.20; and for the Howard method, 0.050. This change consists of moving the decimal points one place to the left.

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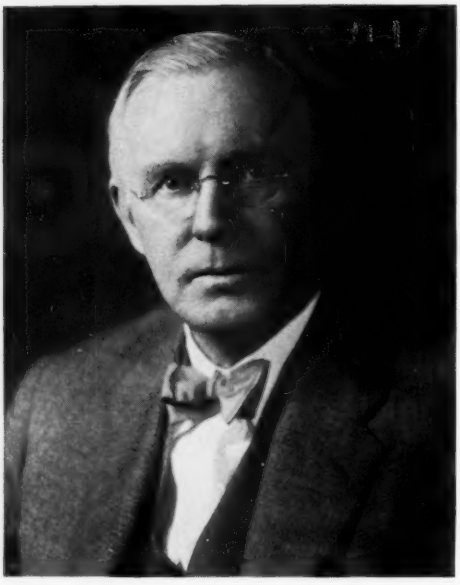

Affectionately dedicated to the revered memory of

JAMES HUFF McCURDY, M.D.

by his associates of

SPRINGFIELD COLLEGE

UNIV. OF MICH.

PREFACE

In his introduction to the first issue of "The Triangle," Dr. Luther Gulick in February, 1891, explained the educational philosophy of Springfield College, symbolized by the equilateral triangle as meaning that man is a unity with three aspects—physical, mental, and spiritual, and that each should be equally developed in relation to each other.

While this Monograph is labeled *Physical Fitness,* the development of the general theme retains the principle outlined above. It seeks to bring together, and interpret, significant selections from the extensive literature, as well as to publish some of the research findings of the College in this field. The endeavor has been made not only to report and evaluate scientific information, but also to indicate significant implications and give aid in the application of these data to actual situations, all in the hope that thereby a higher level of fitness may be attained.

Since this publication is designed for wide distribution there arises at once the dilemma of technical vs. popular language. Some chapters, from the very nature of the subjects treated, require some scientific terminology, but even here the attempt has been made to keep technicalities down to their simpler forms.

The contributing faculty members have been allowed wide liberty as to both content and form of their chapters. There has been no insistence upon uniform recording of bibliographies, so a decided variety exists. Each expresses his personal opinions, uninfluenced by any consideration other than their validity.

Those who have shared in the preparation of material are: John D. Brock, Ph.D.; Walter A. Cox, M.A.; Peter V. Karpovich, M.D.; Leonard A. Larson, Ph.D.; Erastus W. Pennock, M.P.E.; Harold S. Seashore, Ph.D.; George B. Affleck, M.A., Secretary-Editor; Thomas K. Cureton, Ph.D., Chairman.

CHAPTER I

Body Build as a Framework of Reference for Interpreting Physical Fitness and Athletic Performance

By Thomas Kirk Cureton, Jr.
Assisted by Paul Hunsicker*

THE IMPLICATIONS OF BODY BUILD

A GREAT number of studies testify that *body build* or *constitutional type* is basic as a framework of reference in attempts to interpret health, types of physical fitness, athletic performance, and the personality characteristics of human beings. Within the general framework of constitutional types are many detailed aspects to be tested and studied for separate interpretation but, all too frequently, in the focus of attention upon some particular part of the body or type of fitness, the whole person is overlooked. Anthropologists, constitutional psychologists, and medical men have persistently identified themselves with careful clinical observation of the human body and its behavior. More recently, physical educators have revived the ancient study of anthropometry toward improved applications and interpretations to assist in the important individualized *Health and Physical Guidance Work* in schools and social agencies. The need for selecting men fit for air, army, and navy service includes every valid method for selecting and adapting men to tasks requiring unusual physical, mental, and social characteristics.

It may be postulated that the *somatotyping* (body typing) of young men is a fundamental procedure for body mechanics and physical fitness testers. This approach is necessary because almost every type of physical fitness test ultimately must be normed or interpreted in terms of constitutional type. Weight must be interpreted according to type, otherwise it cannot be sensibly analyzed. Likewise, tests of posture, strength, flexibility, endurance, or circulatory-respiratory functions may be understood more clearly in terms of their biological and social significance when viewed against the general background of the constitutional studies. *Somatotyping* attempts to appraise the body in terms of the hereditary quality and quantity of the tissues and organs.

* Paul Hunsicker, graduate assistant in the Body Mechanics and Kinesiology courses, and the following named graduate students assisted in the organization of this study: Arthur Byrnes, Budd Erich, William Hickson, Walter Kerley, Theodore Laurenzo, Harry Lee, Raymond Magwire, Bruce Munro, William Peccole, Herbert Peterson, and Herbert Rhodes.

McCloy [61]* has stated that just as we can purchase ten-dollar suits or hundred dollar suits, so some of us inherit ten dollar organs and others hundred dollar organs. The recent studies published by Sheldon, Stevens, and Tucker [87] present some improved methods for body typing and summarize in vivid fashion the enormous possibilities for differential education adapted to the varieties of human physique. Physical educators should be among the first groups of educational workers to make wide-spread application of the facts and implications of modern morphology and the somatotyping procedures. Tucker and Lessa [94] have summarized and critically interpreted 334 published studies in the general field of body build.

DEFINITION AND SIGNIFICANCE FOR HEALTH AND PHYSICAL EDUCATION

Body build, as a term, means the morphological or structural characteristics (total biological make-up) of the human body as reflecting qualities related to:

1. Health, disease, immunity.
2. Capacity for physical exertion and endurance.
3. Social adaptability through mental and personality attributes.

The modern program of health education will use more fully the results of constitutional appraisals, the extreme *ectomorphs, endomorphs,* and *mesomorphs* receiving help according to their needs. Characteristics of these types are summarized on the following pages.

Using either the subject himself or posed pictures which include the front, back, and side views, each of the five body segments is typed and marked on the score sheet. Silhouettes may be used, as they were in this study, but the results are not reliable except for grouping into gross categories. With each segment the criteria are closely followed while the subject or picture is studied, the final judgment about each segment being marked on the score sheet in terms of a scale ranging from 1 to 7 points for the relative amount of ectomorphic, mesomorphic, or endomorphic characteristics present. Before doing this the type patterns shown in the book, *The Varieties of Human Physique,* should be closely followed. As a further check Sheldon's Table 23A is used wherein the values for Ht./$\sqrt[3]{\text{Wt.}}$ are computed and the possibilities for corresponding type numbers are indicated. The type number which represents the best estimated fit to the subjective judgment is selected.

Form BTS is used for recording the scores.

Physical educators are getting increasingly into guidance work, although athletic coaches and physical education teachers have long had considerable reputation for counselling and guidance service. This is all the more reason for these workers mastering the elements of personality psychology which show the strong association of personality traits with

* Superior figures refer to numbered Bibliography at end of article.

physical types. Kretschmer, [51,52] Stockard,[90] Paterson,[72] and Garrett and Kellogg[89] have outlined these relations. Feeble-minded types are usually retarded in growth or show dysplastic body build characteristics as indicated in the studies of Garvey,[41] Garrett and Schneck,[40] Sheldon,[86] Naccarati,[71] and other workers in this field. The *cycloid* types, or those with manic-depressive temperaments are predominantly pyknic or endomorphic to meso-endomorphic in build; whereas, the *schizoid* types, those who are unsociable, shy, or introverted, and known to be specially susceptible to dementia praecox, are predominantly asthenic or ectomorphic.

HEAVY ATHLETIC BODY TYPE (Mesomorphic)

MORPHOLOGICAL CHARACTERISTICS

I. General Appearance	Squareness and hardness of body Rugged, prominent, massive muscles Large, prominent bones Transverse diameters of shoulders, forearms, and calves are large, but A-P diameters are less than in endomorphic types Central concentration of mass is absent Long and upright trunk, proportions variable Skin is thick and coarse with conspicuous pores; holds good tan—small wrinkles infrequent Hair is coarse, thick, or sparse-baldness appearing first on front of head
II. Segments: 1. Head, Neck, and Face	Head variable in size and shape but often cubical with thick and dense bones Facial bones are prominent, viz: cheek bones, supraorbital ridges; square jaws Facial mass great compared to cephalic mass Fairly long, strong, neck with great transverse diameter compared to anteroposterior diameter Hair on head variable
2. Thoracic Trunk	Predominates in volume over abdominal volume Wide thorax at apex Little thoracic curve in spine Ribs—strong and heavy
3. Arms, Shoulders, and Hands	Shoulders seem low with Trapezius and Deltoidius muscles prominent Broad shoulders Clavicles heavy and prominent Muscular upperarm, no "hamming" Massive forearms, wrists, hands and fingers Upperarm and forearm evenly proportioned
4. Abdominal Trunk and Pelvis	Abdomen is large and heavily muscled, ripples show Slender, low waist Pelvis sturdy and powerful with broad hips Lumbar curves marked
5. Legs, Feet, and Buttocks	Heavily muscled, massive, variable in length Heavy buttocks with dimpling; showing clearly defined muscles Massive forelegs Legs evenly proportioned

IMPROVEMENTS IN METHOD OF BODY TYPING (SOMATOTYPING)

Much confusion has been prevalent over the procedures for accurately classifying the morphological types. Three approaches may be briefly described:

1. *Classification by Subjective Judgment, Holding in Mind the Morphological Characteristics of the Types.*—This approach requires good check lists. The patterns as described by Sheldon, Stevens, and Tucker[87] (pp. 36–50) greatly facilitate this work. The forms used in this study were adapted from their basic work.

LINEAR BODY TYPE (Ectomorphic)

A. MORPHOLOGICAL CHARACTERISTICS

I. General Appearance	Thin body segments, anteroposteriorly Decentralization of structure Linearity, thinness Frail, delicate body structure Small, thin-diameter bones Undernourished appearance Small trunk, long limbs Profuse hair, baldness uncommon
II. Segments: 1. Head, Neck, and Face	Relatively large cranium Bulbous forehead Small face, pointed chin, sharp nose Long, slender neck Poke neck common Lips delicate, thin, dry, pale Abundant hair on head
2. Thoracic Trunk	Narrow thorax, long compared to abdomen Acute costal angle Thin chest depth Clavicular hollows marked, clavicles prominent Winged scapulae, forward shoulders Ribs prominent Kyphosis, marked S curve
3. Arms, Shoulders, and Hands	Long arms, relatively Long forearms, compared to upperarm Thin upperarms, muscles not marked Shoulder droop and round shoulders marked Thin forearms Long thin hands Inconspicuous knuckles
4. Abdominal Trunk and Pelvis	Flat abdomen, hollow above navel Short abdomen, protrusion common below navel Thin anteroposterior depth at navel Lordosis marked, S curve
5. Legs, Feet, and Buttocks	Long legs, relatively Inconspicuous buttocks Long forelegs, relatively Thin thighs, muscles not marked Calves relatively thin Feet thin and long

Young men tend to distribute in a triangular pattern. The big-boned, heavy-muscled group are in the extreme mesomorph area with the middle type number greater than 4. The frail, light-weight types are in the extreme ectomorph area with the third digit in the type numbers greater than 4. The overweight, obese individuals fall in the extreme endomorph section with the first digit in the type number greater than 4. (See illustration I.)

Basically, physical educators should be able to analyze and interpret *physique*. Specific morphological studies, such as those by Sheldon, Stevens, and Tucker,[87] T. Wingate Todd,[54] Graves,[44] Morton,[70] and

LATERAL BODY TYPE (Endomorphic)

A. Morphological Characteristics

I. General Appearance	Large, soft, bulging body Thick body segments, anteroposteriorly Mass concentrated toward center Roundness and softness of body A-P and lateral diameters tend toward equality in the head, neck, trunk, and limbs Large trunk volume over limbs Hair is fine and sparse
II. Segments: 1. Head, Neck, and Face	Large, round, head Short, thick, neck Neck forms obtuse angle with chin in lateral plane Wide, round, face; wide, low, palate Premature baldness common, beginning on top with fine hair texture
2. Thoracic Trunk	Broad, thick, chest Wide costal angle Some fatty breasts Relatively straight spine Postural defects of shoulders not common Clavicular and scapulae hollows well padded
3. Arms, Shoulders, and Hands	Short arms, relatively Short forearms, relatively Limbs taper from "hammy" upperarms to small hands and wrists High, square, shoulders Smooth feminine musculature with no sharp muscle contours, viz: Deltoids and Trapezii Short fingers, relatively
4. Abdominal Trunk and Pelvis	Large abdomen, full above navel and pendulous Long abdomen from xyphoid to pubis Thick A-P depth at navel Relatively straight lumbar spine
5. Legs, Feet, and Buttocks	Short legs, relatively Heavy, fat, buttocks with no dimpling or muscle outlines Short forelegs, relatively Heavy, "hammy" thighs Large, smooth, calves Feet small and weakness common Foot defects common

Vollmer[93] add greatly to the appreciation which examiners have of specific aspects of physique when engaged in body type work.

Athletic performances are affected by *physical capacity* but this term is a composite of many aspects, including structural build in terms of bone, muscle, and fat proportions; including also organic capacity in terms of the functioning of the neuromuscular, digestive, circulatory-respiratory, glandular, autonomic nervous, lymphatic,

FORM BTS

Date .....
Examiner .....
Final Type No. .....
Type Name .....

SUBJECTIVE CLASSIFICATION OF BODY TYPE

Data on Subject:

Name: ....., ..., ...
(last) (first) (initial)

Ht./$\sqrt[3]{}$/Wt. = ——— Class ..... Local Address .....
Sex ..... Race ..... Weight .....
Age ..... Height ..... Nationality .....

Quick Inspectional Classification: Estimated Type Number:

Endomorphy (first component): 1 2 3 4 5 6 7 .....
Mesomorphy (second component): 1 2 3 4 5 6 7 Type Name:
Ectomorphy (third component): 1 2 3 4 5 6 7 .....

Segmental Analysis by Careful Matching with Check Lists *

Region of Body	Endomorphy	Mesomorphy	Ectomorphy
1. Head, Face, and Neck.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Notations:			
2. Thoracic Trunk.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Notations:			
3. Arms, Hands, Shoulders.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Notations:			
4. Abdominal Trunk.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Notations:			
5. Legs and Feet	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Notations:			

* Each component (Endomorphy, Mesomorphy, and Ectomorphy) is rated separately on the seven-point scales by encircling the appropriate numbers.

and excretory systems; and efficient mechanics in the execution of the skills. The persistent attempts by physical educators to classify youths for competition is but a reflection of the fact that many kinds of athletic performances parallel body build and physical development. After 17 years of age, however, body build in terms of the constitutional types is of greater import than the piecemeal and relatively invalid factors of age, weight, height, or other single direct measurements. The indices

ILLUSTRATION I. Distribution of types of physique. (Adapted after the work of Sheldon, Stevens, and Tucker, p. 118.)

of the anthropologists, such as, Wt./Ht., Arm Span/Ht., Bust Ht./Stature, Shoulder Width/Hip Width, Height/Hip Width, Chest Depth/Chest Breadth, etc., to the number of 33 outlined by Tucker and Lessa[94] (pp. 413–414) reflect proportions and physical capacity better than direct measurements of single items.

A basic problem related to all of the body mechanics and corrective work, as well as the normal physical development and conditioning work, is the extent to which body build may be modified through exercise and hygienic procedures. Sheldon, Stevens, and Tucker show that their 76 somatotypes are relatively stable throughout the

post-adolescent years of life, except in the "pyknic practical joke" type. The relative permanency of body type needs to be distinguished from nutritional changes of a transient nature due immediately to changed living habits. Physical development procedures, therefore, have their limitations as seen against the background of the constitutional types. Steinhaus [88] quotes the literature to show that muscular size, strength, and endurance may be developed as the direct result of activity programs but different types respond differently, the ectomorphic types least, whereas the medial types (mesomorphic and balanced proportionate types mixed) show the greatest improvements in muscle girths for equal amounts of exercise. Temporary results of training, such as, the differentiated results shown by Kohlrausch [50] due to comparing the effects of a summer of track and field work with heavy gymnastics, the former reducing muscle girths and the latter increasing them, should not be confused with the relatively more fixed patterns of body type. While heart size, lung capacity, and muscle strengths tend to reflect the amount of strenuous activity done by individuals, the changes vary according to type and should be interpreted against the broad background of the body build triangle.

2. *Classification by Anthropometrical Measurements and Computation of Various Indices of Body Proportions.*—This has been the approach recommended in some of the books on anthropology. Tucker and Lessa[94] (pp. 413–14) give a complete listing of 33 such indices. Montessori [69] (p. 75) states the canons of bodily form to be:

Brachysceles (*Lateral-Endomorphic*)	Mesatiscles (*Medial-Mesomorphic*)	Macrosceles (*Linear-Ectomorphic*)
Stature $>$ Arm Span	Stature $=$ Arm Span	Stature $<$ Arm Span
Bust Height $>$ Stature/2	Bust Height $=$ Stature/2	Bust Height $<$ Stature/2
Chest Girth $>$ Stature/2	Chest Girth $=$ Stature/2	Chest Girth $<$ Stature/2

Arnold [2] (pp. 99-101) gives the means of all indices for the body types as classified by Kretschmer (metric units):

	Leptosome	Muscular	Pyknic
Body Build Index	Up to 2.00	2.15 and over	2.35 and over
Fat Pads	Up to 9.0	15.0 and over	20.0 and over
$\frac{\text{Chest Girth}^2}{\text{Ht.}}$	Up to 43.0	46.5 and over	50.0 and over

The difficulty with these indices is that they fail to show multimodal distributions on frequency histograms following the assumption

that a given population would show modal groupings around the three major types. For this reason the use of indices fell into disrepute with some statisticians. Sheldon-Stevens-Tucker[87] (p. 118) show in their two-dimensional triangular diagram of the distribution of their somatotypes that the greatest majority of the people are not extremes but combination types possessing some of the three components of *endomorphy, mesomorphy,* and *ectomorphy.* The newer point of view of these authors shows clearly that the person who is high in mesomorphy is not mid-way between the extremes of endomorphy and ectomorphy. They conclude that the types cannot be represented by a continuum ranging between these extremes. Therefore, the usual geometry of normal curve statistics does not fit. Two persons of very different type may have the same indices, although the chances of this are not great at the extremes of the distribution.

Other difficulties develop due to lack of clarity about what the indices mean. For instance, what does Wt./Ht.^{2} mean? Various types can give the same index result. The fit of this index is fair for ectomorphs and mesomorphic-ectomorphs but it may fail to accurately classify the mesomorphs. The relative efficiency of 14 items was tested by classifying a group of 96 Springfield College men by subjective procedure. This work was carefully checked over a second time, at least three examiners finally agreeing on the type number to be given. The ponderal index was also computed and the result matched with Sheldon's type numbers. Any difference was rectified. The result gave:

Ectomorphs	14	14.58%
Meso-Ectomorphs	60	62.50%
Mesomorphs	19	19.79%
Meso-Endomorphs	3	3.13%
Endomorphs	0	
	N = 96	100.00%

Each of the indices was computed for the men in each classification. The range of each index was determined within each class and the percentage that this was of the total range of the index for all types was computed. Thus, the sharpness with which the index discriminated the types was determined. For instance, there were the following comparisons for the Ht./$\sqrt[3]{}$Wt. index:

Subjective Classification		*Per Cent Range for Index*	*Approximate Error of Fit*
Ectomorphs	14.58%	28.3%	13.7%*
Meso-Ectomorphs	62.50%	58.5%	4.0%
Mesomorphs	19.79%	51.4%	31.6%
Meso-Endomorphs	3.13%	28.7%	25.6%
Endomorphs			
	100.00%		

*The per cent of *number of cases* is not exactly comparable with the per cent of the *total range of measurement,* i.e., the area under the portion of the frequency curve involved is not exactly the same as the dimension on the base axis. The per cents are not computed on the same base. Nevertheless, the comparison has considerable validity.

The conclusion reached here is that the index is fairly good only for the meso-ectomorphic class. It is obvious that there is much overlapping and that the index alone is not very good for producing results which are like the subjective results.

On the basis of all-round fitness the items used rank for efficiency as follows (refer to Table I for the evidence):

	Relative Rank for Classifying Types			
	Ectomorphs	*Meso-Ectos.*	*Mesomorphs*	*Meso-Endos.*
1. Arm Span/Ht.	6	1	1	2
2. Sit. Ht./St. Ht.	1	4	2	5
3. Shoulder W./Hip. W.	7	2	4	1
4. Wt./Ht.^{2}	3	5	12	4
5. Wt.	11	6	3	8
6. Ht./Hip. W.	10	3	7	9
7. Wt./Chest Girth	8	7	5	10
8. Age	5	13	11	3
9. Ht.$\sqrt[3]{\text{Wt.}}$	4	9	10	11
10. Wt./Ht.	9	11	9	6
11. $\sqrt[3]{\text{Wt.}}$/Ht.	2	8	14	12
12. Chest Depth/Width	12	10	6	7
13. Sitting Height	14	14	8	13
14. Height	13	12	13	14

It is clear from the above tabulations that the indices and measurements vary greatly in their efficiency in picking out the proper persons and the right number of them for each classified group.[1]

Furthermore, study of the progressive increase or decrease in the means given for each index for each class, (Table I) reveals other difficulties. For instance, with age, sitting height, sitting height/standing height, and arm span/height the highest ratios are in the meso-ectomorphic and mesomorphic groups with some tapering off toward both extremes. With all others there is some progression from extreme ectomorphy to extreme endomorphy, the values for meso-ectomorphs and mesomorphs being in the middle as they should, following the continuum assumption. The chest depth/chest width and the shoulder width/hip width indices do not differentiate between the two middle classes of meso-ectomorphs and mesomorphs.

Some of the difficulties of determining correlational validity co-

[1] Tucker and Lessa state that Kretschmer depended upon observing carefully the whole body, using a few direct measurements but no indices. They summarize his approach by "Everything depends upon a complete, artistic, and sure schooling of our eyes, for a scholarly list of single measurements without any idea of intuition of the general structure will not bring us much further. The tape measure sees nothing; it never leads us to a grasp of the biological types which are our object."

efficients may be anticipated. Some of these indices do not make good continuum scales. The correlations with other types of continuous performance scales would probably be much lower than the real relationship between accurately determined body types and corresponding performances on athletic or organic efficiency tests. No good scheme has been developed for composing the various index results into a composite body type score. It probably will never be done satisfactorily.

The conclusion is reached that it is helpful to know the values of some of the indexes in studying individual persons or types of build associated most successfully or unsuccessfully with athletic performances or organic capacity tests but there is no simple, objective, valid method of using these indexes to determine body type in the same sense that the subjective method with check lists provides.

3. *The Sheldon-Stevens-Tucker Somatotyping Procedure.*—This procedure is perhaps the most reliable and valid method known for determining body type according to the criteria outlined by these authors.[87] Briefly, it consists of taking good three-view photographs

TABLE I

DISCRIMINATING EFFICIENCY OF VARIOUS INDICES

	Ectomorphic Class N = 14 (14.58% of cases in class)			Mesomorphic-Ectomorphic Class N = 60 (62.50% of cases in class)		
Index N = 96	Mean Value	Range of Values for Ectomorphic Class	Per Cent of Range for All Classes	Mean Value	Range of Values for Meso-Ectomorphic Class	Per Cent of Range for All Classes
ge (Years)	18.3	16.2–20.3	29.3%	19.7	16.0–27.0	78.6%
eight (Inches)	69.4	63.0–75.0	80.0%	69.4	64.0–75.0	73.4%
eight (Pounds)	140.7	105–180	56.0%	152.4	130–192	46.3%
tting Height (Inches)	36.2	32.2–39.3	88.8%	36.4	34.0–40.5	81.2%
eight/Height	2.00	1.70–2.40	53.5%	2.23	1.90–2.80	68.7%
t./Ht.^{2} × 100	2.63	2.63–3.20	26.5%	3.17	2.73–3.68	44.2%
/Wt./Ht. × 100	7.48	7.23–7.66	26.1%	7.68	7.18–8.11	56.4%
t./$\sqrt[3]{\text{Wt.}}$	13.37	13.06–13.83	28.3%	13.01	12.33–13.92	58.5%
tting Ht./Standing Ht.	.519	.50–.54	25.0%	.520	.50–.57	43.8%
t./Chest Girth	4.10	3.44–4.74	51.2%	4.46	4.06–5.28	48.1%
t./Hip Width	6.27	5.25–6.73	54.8%	6.17	5.58–6.67	40.4%
rm Span/Height	1.04	.99–1.10	30.6%	1.05	.98–1.10	33.3%
hest Depth/Chest Width	.67	.49–.80	64.6%	.69	.57–.89	66.7%
houlder Width/ Hip Width	1.41	1.54–1.24	33.3%	1.39	1.56–1.22	37.4%

TABLE I (Continued)

DISCRIMINATING EFFICIENCY OF VARIOUS INDICES

Index N = 96	Mesomorphic Class N = 19 (19.79% of cases in class) Mean Value	Range of Values for Mesomorphic Class	Per Cent of Range for All Classes	Mesomorphic-Endomorphic Class N = 3 (3.13% of cases in class) Mean Value	Range of Values for Meso-Endomorphic Class	Per Cent of Range for All Classes
Age (Years)	20.2	17.8–25.0	51.50%	18.7	18.0–20.0	14.28%
Height (Inches)	67.3	62.0–71.0	60.00%	67.3	63.0–72.0	60.0%
Weight (Pounds)	163.9	150–185	26.1%	177	156–190	25.4%
Sitting Height (Inches)	35.7	33.6–37.0	42.5%	35.3	34.0–37.0	37.5%
Weight/Height	2.44	2.18–2.80	47.3%	2.62	2.47–2.76	22.1%
Wt./Ht.^{2} × 100	3.62	3.08–4.25	3.62%	3.90	3.67–4.12	16.28%
$\sqrt[3]{}$Wt./Ht. × 100	8.14	7.57–8.76	72.2%	8.34	7.99–8.52	32.2%
Ht./$\sqrt[3]{}$Wt.	12.31	11.42–12.82	51.4%	12.01	11.74–12.52	28.7%
Sitting Ht./Standing Ht.	.530	.51–.55	25.0%	.527	.51–.54	18.75%
Wt./Chest Girth	4.68	4.27–5.00	28.7%	4.98	4.70–5.40	27.60%
Ht./Hip Width	5.94	5.44–6.35	33.7%	5.87	5.60–6.30	25.00%
Arm Span/Height	1.05	.99–1.07	22.2%	1.03	1.01–1.05	11.1%
Chest Depth/Chest Width	.68	.63–.79	33.3%	.75	.70–.81	22.9%
Shoulder Width/ Hip Width	1.39	1.52–1.27	27.5%	1.34	1.40–1.31	9.90%

and scaling 17 diameters from these. Each of the measurements is divided by height. Then various ratios are computed which are located on scales furnished in the text. A system of minimum deviations is outlined for deciding the type, although a machine greatly simplifies the labor of determining the mean rank of a given somatotype from 18 rows of lights showing the deviations on each index scale.

CONSTITUTIONAL TYPE AND HEALTH

Body Type Effective in Broad Classifications for Health.—Health is an aggregate term, the composite of all types of physical fitness. It is a valid concept but difficult to measure with objective tests because of their limited and specific nature. If there is any basis upon which a prediction of health over life as a whole may be predicated, it is possibly the constitutional type basis. In general, the types 127, 126, 235, 136, 245, 244, 154, and 163, in other words, those high in ectomorphy and low in endomorphy are the virile, long lived types with remarkable immunity to most types of fatal diseases. The types low in meso-

morphy (muscular and bony development) are usually hypopituitary types, with poor posture, weak musculature and are low in endurance and energy for living. These types include those numbered 217, 216, 316, 415, 515, 514, 613, 612, 712 and 424. Those types extremely high in endomorphy are susceptible to many of the most serious diseases, are relatively short lived, and are harmfully overweight as a rule. Persons extremely high in mesomorphy are the energetic, healthy types, although not noted for longevity. They have strength and ruggedness, make good athletes, and are subject to few ailments. Only minor difficulties seem to appear in this group including acne, muscle-bound condition, and overweight condition in later life, perhaps of a less harmful kind as it is typically better distributed over the body. Throughout this broad picture, muscular types seem to have a health advantage for active living. They represent good "selections" for army and navy recruits.

Tucker and Lessa[94] (pp. 424–436), Sheldon, Stevens, and Tucker[87] (pp. 10–28), and Pearl, Sutton, and Howard[74] are among the many writers who have discussed the relations of constitutional type to immunity or disease susceptibility. In general, these workers imply that the medical profession, as well as Health and Physical Educators, have ignored the important implications of this field and have failed to create methods to implement its use in diagnosis and prescription. The medical men have occupied themselves predominantly with diseases, micro-örganisms, pharmacology, immunology, and often neglected the broad patterns of man himself. Likewise, health educators have been absorbed in the facts of hygiene and practices usually undifferentiated as to constitutional strengths and weaknesses, and physical educators have been concerned with the development of skill, also at times in a manner unrelated to the basic constitutional type needs and abilities of the individuals.

The older anthropologists advanced the theory of the *medial man*, holding that in the relationship to the physiological laws of health, the combination in a single individual of the maximum number of average characteristics gives the type that escapes diseases and predisposition to disease and that such a type is sounder, more robust, and more handsome. Montessori[69] summarizes some of these works, particularly those of Sergi, Quetelet, Achille di Giovanni, and Viola, who pioneered the work in body build, considering it one of the great developments in medical history. di Giovanni[82] maintained as a result of extensive studies that a chief cause of morbidity resides in disproportionate development of some organs or tissues relative to others.

Benecke[91] (1878–81) was the first to measure the internal organs and associate them with age, disease, and external characteristics of body type.

Pearl and Pearl,[75] and Pearl and Moffett[77] point out the superior

longevity of the linear and medial types. Pearl [73] concluded that extreme ectomorphic types are susceptible to tuberculosis and are especially in need of preventive hygiene. This finding is supported in further studies by Barker.[5] Even more striking relationships may be shown with the improved somatotyping procedures and valid statistical procedures.

Reed and Love[80] in their studies of army officers show some definite somatological norms for various diseases, similar studies having been presented by Draper[33,34] for non-military subjects. Likewise, Petersen[79] reviews a number of studies which show the association between constitutional type and disease.

Goldthwaite[42,43] summarizes the body type studies which explain many of the fundamental problems of body mechanics. Such studies include those by Hutchinson[49] and Weisman[96] who studied the type of chest most prevalent in tubercular cases, and Mills[67] who showed the relations between posture and visceral form, position, tonus, and motility.

Bruenn and Dypertius[12] show differences in the cardiogram tracings and Ciocco[15] related some of the types of heart disease to constitutional type.

Health education programs, such as Bartels',[6] offering a gymnastic and dietary program for pyknic types, are in their infancy. Sheldon, Stevens, and Tucker[87] make some interesting suggestions about diet, athletic ambition, mating, housing, and other variables in a differentiated program for different types of individuals.

CONSTITUTIONAL TYPE AND ATHLETIC PERFORMANCE

1. *Gross Relationships of Type to Performance.*—Generally, athletic performance will parallel growth and development year by year up until 17 years of age for boys. Combinations of age, height, and weight make reasonably good bases for norming athletic performance up to this point. However, the graphs in the Schwartz, Britten, and Thompson studies[84] (pp. 39–106) show that at 17 years of age the curves for height, weight, and practically all other items of growth and development stop their sharp vertical climb and level off, indicating little variation with age between 17 and 30 years. Likewise, items like strength and vital capacity which vary with height and weight, approach a plateau and do not change much with age in the 17-30 year span. Age and weight become very poor bases for norming athletic performances or strength in this span. Other factors are of much greater significance, such as, the quality of the muscle tissue, specific neuromuscular learning, internal leverage arrangements, experience, and other types of physical adaptations required by the particular activity. A large number of these are known and some of these have been discussed at length in body mechanics articles by the writer.[18–26]

In general, people with long legs and arms and relatively short and small trunks are physically weak types in long sustained heavy work but they might show great speed and endurance at light athletic work. Long third class levers are noted for speed and range of action as well as their efficiency for force. Amar[1] (pp. 129–30) points out that people of small stature are relatively stronger than tall ones, and quicker because weight decreases as the cube of the size, whilst force decreases only as the square, being approximately proportional to the cross-section of the muscle. Short, heavy set, people are remarkably strong and make good weight lifters, carters, and heavy laborers. The "grasshopper" types with relatively long legs (particularly forelegs) make good jumpers, runners, vaulters, hurdlers, and agility athletes.

Within certain limits, therefore, athletes do run to type as was pointed out by Sargent in 1887,[83] by Boardman in 1923,[10] but more recently verified scientifically in studies like those of Kohlrausch [50] and Arnold.[2] Most important are the exact relationships of muscle mechanics and the grosser organization of the body for balance, range and direction of the movements, leverage for force, speed, and power. Illustration I shows an approximate distribution of these types. Many more studies need to be made to clarify these important relationships.

McCloy[60] (pp. 63–101) after critically appraising the various age, height, weight classification schemes concludes that after 17 years age is not a significant variable and his recommended index becomes:

Classification Index for Athletic Performance = 6 Ht. (inches) + Wt. (pounds).

Bookwalter[11] concludes that the Rogers' Strength Index makes the best classification index in arranging large groups of young men into competitive or instructional groups. Bartlett [8] demonstrated that chinning alone was approximately three times as good as the best combination of age, height, and weight. Larson[56] has combined chinning, dipping, and vertical jumping for an efficient device in classifying young men.

The fact that total strength in adult males correlates as high as .61 with skeletal build, as shown by Lookabaugh[58] suggests at once a good relationship between strength and power types of athletic performances and body build since indices of the latter are composed largely of skeletal measurements. This relationship may be compared with correlations of below .30 for net age, height, and weight relationships for young men.

Cozens[17] in a study of 408 unselected college men demonstrated that there is a negligible correlation between age and height, and between age and weight. Using 3965 University of California at Los Angeles freshmen, Cozens grouped the men into nine classes:

25% Tall: (5′–10½″)—slender, medium, heavy
50% Medium: (5′–7″ to 5′–10″)—slender, medium, heavy
25% Short: (below 5′–6¾″)—slender, medium, heavy

With 601 of these cases it was demonstrated that the tall and medium men were superior to the short, and the heavy and medium heavy men were superior to the slender. The criterion of athletic ability was Cozens' *All-Round Athletic Ability Test* (7 items). Being slender and scoring high on this test correlates —.355; whereas, being heavy and scoring high correlates .312. Being short and scoring high correlates —.251.

2. *Track and Field Ability and Body Build.*—Sargent [83] concluded that sprint runners were typically light boned men with relatively long limbs and full-chested bodies. He thought that a relatively long foreleg would be helpful. Kohlrausch [50] studied the contestants at the 1928 Olympic games, at Amsterdam, and discovered the 22 best sprinters in the world to be 142.3 lbs. in weight, 67.9 inches in height, with a weight/height index of 2.17, and a vital capacity of 4300 c.c., as average measurements. The 400-meter runners were slightly taller (69.2″), heavier (143.7 lbs.) and more linear (2.10), with 4500 c.c. for vital capacity. The middle distance runners averaged 146.7 lbs., 68.9 inches in height, 2.19 for body build, and 4800 c.c. lung capacity. The long distance runners averaged 132.7 pounds in weight, 66.8 inches tall, 2.10 for body build, and 4300 c.c. for vital capacity. Jumpers were found to be tall types with long legs and quite slender. Vaulters, hurdlers, and middle distance runners are quite similar in build. Kohlrausch gives an excellent discussion of the results on more than 300 athletes measured at Amsterdam. He arranged these into 15 sport types but these again could be grouped into three major classes:

Slender Types—runners, jumpers, hurdlers, with relatively long legs and slender bodies.

Medium Types—decathlon and pentathlon athletes, boxers, ball players, and swimmers.

Massive Types—weight throwers, weight lifters, wrestlers, and up to a point gymnasts.

Arnold [2] reviews the studies of Böning, Kruemmel, Schwarze, Rautmann, Kohlrausch, and Bach. German athletes are classified as:

Gymnastic Types—relatively long hulk coupled with breadth.

Wrestlers—mighty forms with great breadth of shoulders and pelvis coupled with great breadth and depth of chests.

Pentathlon Types—medium to slender types with relatively longer legs and less breadth.

Bemies[9] in a much older study made in 1900, demonstrated similar trends on five outstanding track athletes compared with the average measurements of 2300 Yale University students. The runners and jumpers were found to be about 2″ above average in height, an inch greater in arm reach, with longer legs and the lower leg being an inch longer than in other students of the same height. The calf averaged smaller and the thigh was 2/10ths of an inch shorter. The hips were an inch narrower. He suggested that these leg proportions gave a quick acting

upper leg and a long reach with the lower. The track athletes had a deeper, more rounded form of the chest with greater vital capacity. A study by Davenport [80] on the *crural index* (ratio of lower leg length × 100 to length of thigh) is always higher in jumping animals. Reviewing his own studies and those of W. K. Gregory covering 53 species, those with indices above 120 are jumping animals, such as, the hare-like Pedetes caffer (South Africa) able to clear 20–30 feet in a single bound. Man is in a relatively slow running class (82–90) with the camel, bear, chimpanzee, gorilla. The crural index is higher in man just before adolescence, approaching 90, and then diminishes to 84 in the adult. Davenport states it recapitulates the phylogeny.

Krakower[53] in studying the skeletal characteristics of high jumpers concluded that they had longer legs, greater height, and broader feet giving a prediction formula for high jumping based upon skeletal measurements as follows:

Height of Jump (cm.) $= -.494$ (Height cm.) $+ 1.522$ (Length of Legs cm.) $+ .338$ (Breadth of Foot mm.) $+ 57.818$. $R = .438$.

At Springfield College 113 freshmen of the class of 1932 were classified as linear, medial, and lateral in body build. The same men were tested in five track events. The linear types showed better ability in the baseball throw, standing broad jump, 50-yard dash and 440-yard run. The lateral types were superior in shot putting.

TABLE II

BODY BUILD AND TRACK PERFORMANCE

Events (113 cases)	Linear Type (mean)	Medial Type (mean)	Lateral Type (mean)
Baseball throw	228.38 ft.	225.56 ft.	204.11 ft.
Shot-put (16 lbs.)	28.81 ft.	33.24 ft.	33.70 ft.
Standing broad jump	7.90 ft.	7.87 ft.	7.76 ft.
50-yard dash	6.33 sec.	6.47 sec.	6.54 sec.
440-yard run	67.03 sec.	69.10 sec.	72.33 sec.

In another study of 103 Springfield College freshmen the neck girths of the linear, medial, and lateral groups averaged 13.0″, 14.0″, and 14.75″ to correspond respectively to mean shot putting performances of 27′–8¼″, 30′–3¼″, and 31′–1¼″. Calf girth correlated .117 ± .066 with 440-yard running time. Vital capacity and 440-yard running time correlated .181 ± .060.

In the baseball throw, the men were divided into equal thirds according to their performance in this sport event. The best third averaged 262.21 ft. corresponding to average measurements for arm span 180.54 cm., weight 152.73 pounds, height 175.58 cm., hand grip (right plus left) of 215.45 pounds. The second group averaged 225.41 ft. corresponding to average measurements for arm span 175.47 cm., weight 151.10 pounds, height 174.60 cm., grip 204.26 pounds. These

measurements are all correspondingly lower. The third group averaged 181.25 ft. corresponding to arm span 176.86 cm., weight 146.41 pounds, height 173.36 cm., grip 203.31 pounds. It is clear that the taller, heavier, stronger men with greater arm span have the better average performances in this event.

3. *Swimming and Body Build.*—Cureton[18] studied the Olympic swimmers at the 1932 and 1936 Olympic games, taking a variety of physical measurements. Sprint swimmers are forceful, testing high in arm, leg, and body strengths. The American swimmers are taller than

TABLE III

Body Build of Olympic Swimmers

Group	No.	Height (inches)	Weight (pounds)	Wt./Ht.	Wt./Ht.^{3}	Chest Girth (inches)
American Olympic Men, 1932	18	71.19	160.1	2.25	3.16	37.8
American Olympic Men, 1936	13	71.90	171.7	2.53	3.32	36.2
Springfield College Varsity Team	25	70.17	161.5	2.30	3.28	37.9
Springfield Freshmen (whole class)	150	68.69	147.1	2.14	3.12	35.3
Japanese Olympic Relay Team (world's record)	4	67.67	142.2	2.10	3.10	35.75
Japanese Olympic Team, Men	13	66.00	141.6	2.15	2.82	34.3

average and represent close approximations to 343 and 454 somatotypes. Extremes are very unusual. The middle distance swimmers were found to be unusually superior in vertical and horizontal floating capacity with great vital capacity and more than the average amount of adipose tissue. Their relatively great floating capacity suggests light bones and less dense muscular tissue, a trend toward endomorphy. Terada, the 1936 Olympic 1500 meter champion would approximate a 552 somatotype; Uto, his teammate, would be a 462. Medica, 1932 Olympic 440-yard champion would approximate a 552. Ralph Flanagan would be appraised as a 353. Makino and Kitamura, 400-meter and 1500-meter stars of the Japanese Olympic team of 1932 would be 345 types. The Hawaiian stars K. Nakama and B. Nakama, American Champions at 220, 440, 880 yards and the mile are very small men, strong and wiry, who ride very high in the water. They would be appraised as 355 types.

There are no extreme ectomorphs or endomorphs in the competitive swimming group. All are average or above in strength, the sprinters trending toward ecto-mesomorphy and the middle distance swimmers toward endo-mesomorphy.

THE PHYSIQUE AND FITNESS OF SPRINGFIELD COLLEGE MEN

Springfield Men, Selected Group of Fit Men.—The Springfield College undergraduates represent an unusual selection of men adapted to heavy participation of physical activities. About 90 per cent of the men play on some varsity team. Approximately 60 per cent of the students are physical education majors, and the others are selected because of their interest and desire for service with youth groups. These men are activity minded, wholesome living, hard working college boys with a mean age of 20.87 years. Possibly nowhere in the United States is there a more select group of athletic men, except possibly in the U. S. Military Academy or U. S. Naval Academy or some similar group of trained men.

Norms Make Good Goals for Fit Groups.—The norms on the Springfield freshmen make an interesting set of standards. It would be interesting to compare other groups with the Springfield figures. With the test scores in hand, any individual can compare his own physique and fitness with these results. Normative scales may be expanded from the data of Tables V, VI, and VII.

The Body Build of Springfield Men.—In the winter of 1940-41, 585 cases of Springfield freshmen were typed using form BTS and the morphological criteria of Sheldon, Stevens, and Tucker. Five classifications were used and the men distributed themselves as follows (see Illus. II):

Moderate Ectomorphs	72	12.22%
Ecto-Mesomorphs	231	39.58%
Mesomorphs	259	44.27%
Meso-Endomorphs	20	3.42%
Moderate Endomorphs	3	.51%
	585	100.00%

Reliability.—Eleven graduate students assisted the writer with the *somatotyping*. The procedure used was subjective classification using as fully as possible the separate criteria and check lists for *endomorphy, mesomorphy,* and *ectomorphy*. The reliability of the work of the graduate students was from .70 to .93 but each of the cases was inspected by the writer before the final type number was given. The Ht./$\sqrt[3]{}$Wt. index was computed and the type number adjusted to Sheldon's Table 23 A.

The Physique of Springfield Men.—The results are shown in Tables V and VI including some comparisons with Yale freshmen.* In Table V the various body build ratios are shown for the Springfield men.

Table VI shows that in comparison with the Yale men the Springfield College men average 3.35 lbs. heavier and have slightly greater abdominal girths by 1.29 inches, although they are shorter by 1.67

*The data on the Yale men were submitted by J. S. Wickens, Yale University.

TABLE V

SPRINGFIELD COLLEGE BODY BUILD INDICES
(Data 1935–40)

Item	Units	Coefficient of Variability	N.	Range	S. D.	-3σ	-2σ	$-\sigma$	M	$+\sigma$	$+2\sigma$	$+3\sigma$
Age	Years	11.56	804	17–31	2.41	17	Skewed	Data	20.87	Skewed	Data	31
Height	Inches	3.36	811	62–77	2.30	77	73.4	70.84	68.54	66.24	63.94	62
Sitting height	Inches	3.70	797	32–40	1.33	32	33.29	34.62	35.95	37.28	38.61	40
Weight	Pounds	10.95	777	106–240	17.30	106	124	141	158	176	192	240
Wt./ht.	lbs./ins.	9.78	509	1.60–2.91	.22	1.60	1.81	2.03	2.25	2.47	2.69	2.91
Wt./ht.^{2} × 100	lbs./ins.	9.94	804	2.25–4.40	.32	2.25	2.58	2.90	3.22	3.54	3.86	4.40
$\sqrt[3]{}$Wt./ht. × 100	lbs./ins.	3.47	793	7.0–8.65	.27	7.00	7.23	7.51	7.78	8.05	8.32	8.65
Sitting ht./standing ht.	ins./ins.	3.33	797	.44–.60	.017	.44	.479	.496	.513	.530	.547	.60
Wt./chest girth	lbs./ins.	8.91	701	5.75–3.21	.39	3.25	3.60	3.99	4.38	4.77	5.16	5.55
Ht./hip width	ins./ins.	6.92	701	7.40–4.70	.415	7.40	6.83	6.42	6.00	5.59	5.17	4.70
Arm span/ht.	ins./ins.	3.08	714	.82–1.18	.032	1.18	1.10	1.07	1.04	1.01	.98	.82
Chest depth/chest width	ins./ins.	9.62	711	.46–.94	.065	4.60	.546	.611	.676	.741	.806	.94
Shoulder width/hip width	ins./ins.	15.10	710	1.71–.80	.19	Skewed	1.71	1.45	1.26	1.11	.99	.80
Chest girth/abdominal girth	ins./ins.	5.78	268	1.00–1.35	.065	Skewed	1.00	1.06	1.13	1.19	1.33	1.27
Ht./$\sqrt[3]{}$wt.	ins./ins.	3.50	793	14.29–11.57	.45	14.27	13.83	13.32	12.86	12.42	12.02	11.57

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(551)
20.7 YRS.
66.4 MOS.

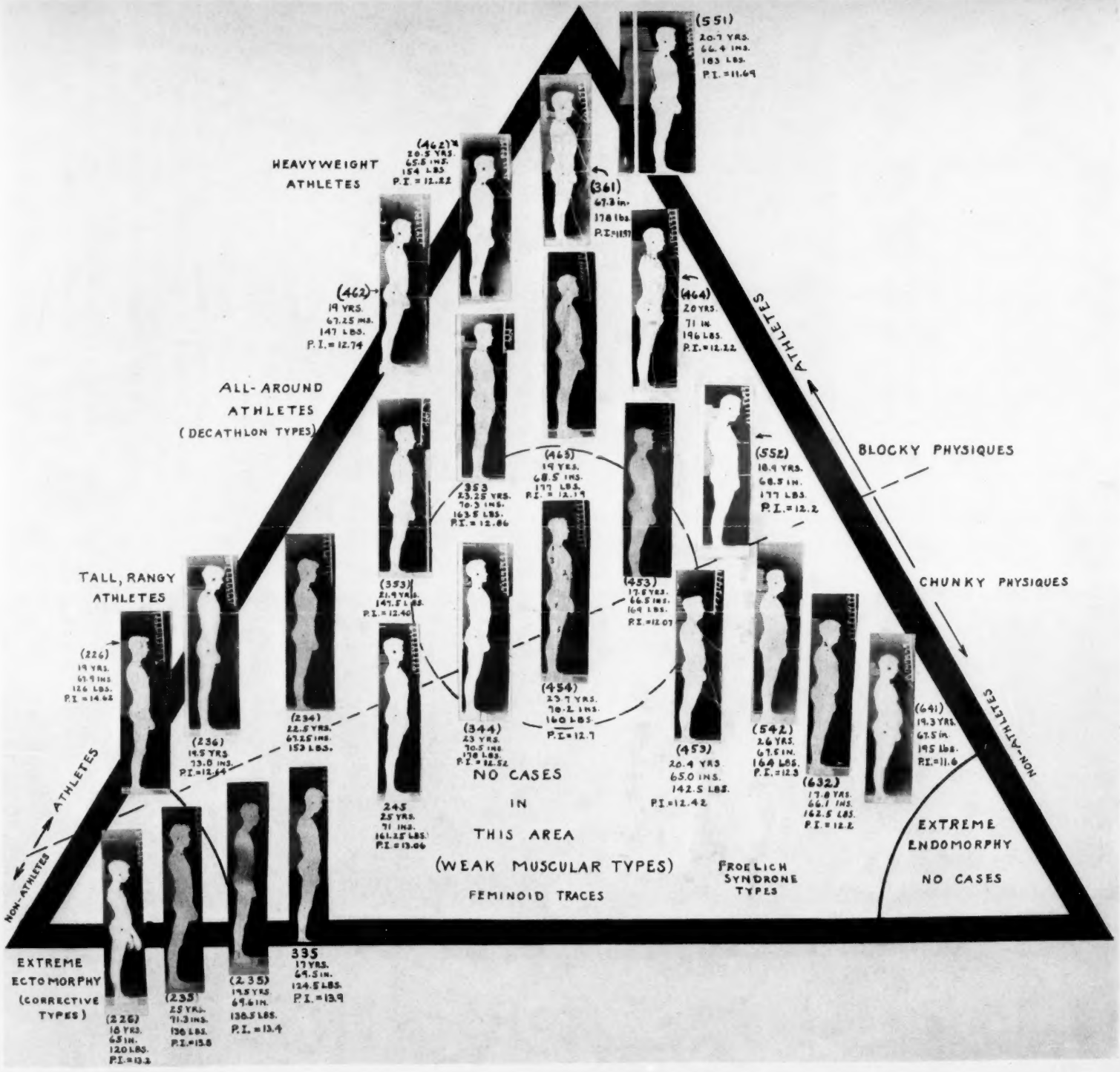

ILLUSTRATION II. Variation of physiques among Springfield men. (Note: the somatotype numbers are estimates by inspection, guided by the ponderal index reciprocal P.I. = Ht./$\sqrt[3]{}$Wt. and the corresponding table 23A, p. 268, in the Sheldon-Stevens-Tucker text.)

inches than the Yale men. This gives the Springfield men a higher index of body build as shown on CHART I, the Springfield mean ratio being 3.22 compared to 3.08 for the Yale men and 2.31 for the Davenport adult data. The heaviness is probably due to more mesomorphic types being in the Springfield group than in the Yale group. The lower mean in height may possibly be attributed to the fact that extremely tall ectomorphs do not do well in the heavy muscular and all-round athletic program of Springfield College, hence, they have been eliminated by selection or by dropping.

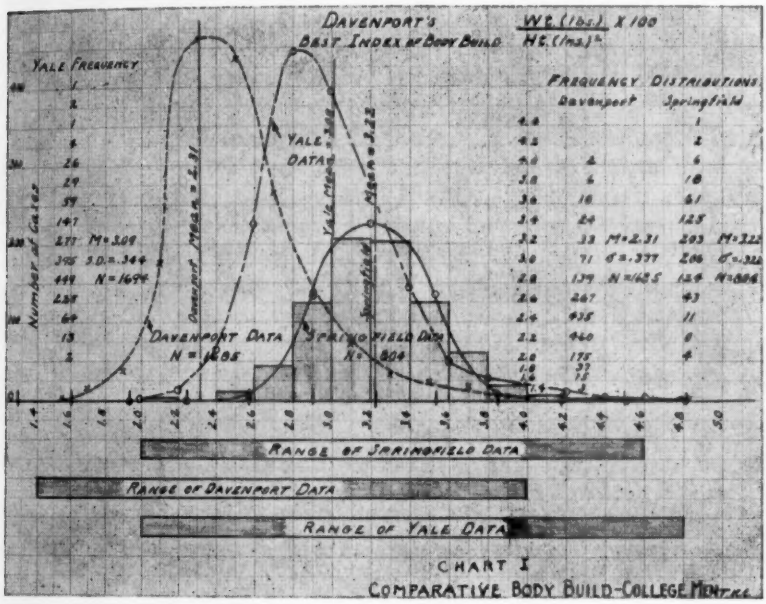

CHART I
COMPARATIVE BODY BUILD-COLLEGE MEN

From Table VI it may be noted that the Springfield men have rather long arms for their height.

Diehl [31] gives the mean height for young males 17-21 years of age as 68.70 inches, and quotes the Medico-Actuarial Data as 67.02 inches, the data of Love and Berkson on 100,000 C.M.T.C. students as 67.90 inches, and the army recruits by Hoffman as 67.06 inches. These figures may be compared with the mean Springfield height of 68.54.

Diehl also gives the mean weights of 23,122 college students as 142.12 pounds, Medico-Actuarial data as 137.25 pounds, and the C.M.T.C. men as 136.72 pounds. The Springfield mean is 158.35 pounds, 16.23 pounds above the highest of these. This is probably evidence of muscular development.

Diehl's figures for the Wt./Ht.^{2} index show the mean for all college students to be 30.55, and the C.M.T.C. students 29.65. Gammon[38] re-

ports the median of 29.0 for 1765 freshmen who entered the University of Pennsylvania in the years 1931-32. The Springfield College mean is 32.2, indicating a heavier and shorter build, trending toward the stocky type, relatively as compared with these other groups. However,

TABLE VI

COMPARISON OF SPRINGFIELD MEN AND YALE MEN ON PHYSICAL INDICES

Item	Springfield Men				Yale Men			
	N	Range	σ	Mean	Mean	σ	Range	N
Weight	777	102–232	17.3	158.35	155	17.66	115–215	227
Standing Height	811	62.8–77	2.30	68.54	70.21	2.43	64.5–80.5	253
Sitting Height	797	32.3–39.8	1.33	35.95	36.52	1.22	33.8–40.3	253
Abdominal Girth	239	24.5–38.5	2.14	30.79	29.50	2.00	25.5–38.5	245
Arm Span	273	62–78	3.00	70.73	72.82	2.78	64.5–80.5	245
Chest Girth	644	28.7–41.3	2.10	35.00	35.19	2.08	30.5–41.5	244
Chest Depth	645	5.8–10.0	.79	7.9	8.29	.66	6.25–10.25	227
Chest Breadth	297	9.75–15.0	.73	11.76	11.90	.72	10.25–14.75	228
Weight (in.)/ Height (in.)	509	1.60–2.91	.22	2.25	2.16	.25	1.40–3.60	837
Weight/ Height^2 × 100	804	2.25–4.40	.32	3.22	3.09	.34	2.00–4.80	1694
Sitting Ht./ Standing Ht.	797	.44–.60	.02	.513	.521	.01	.46–.55	269
Arm Span/ Height	714	.82–1.18	.03	1.04	1.04	.02	.97–1.10	260
Chest Depth/ Chest Breadth	711	.46–.94	.065	.676	.670	.05	.53–.82	294
Chest Girth/ Abdom. Girth	268	1.00–1.35	.065	1.125	1.198	.05	1.04–1.36	425
Height/$\sqrt[3]{\text{Wt.}}$	793	11.57–14.29	.45	12.86	13.19	.50	11.2–14.6	837

these college freshmen groups fall into the slender or medium classification according to Gammon's groupings:

Very slender .....20.5–25.4 (Ectomorphic)*
Slender 25.5–30.4
Medium .....30.5–36.4 (Meso-Ectomorphic)
Fat .....36.5–43.4 (Mesomorphic)
Very Fat .....43.5–64.4 (Endomorphic)

Body Build and Performance in Athletics and Condition Tests Related to Body Type.—Table VII shows that most of the athletic performances involving strength and power give the highest mean scores to the *mesomorphic* class with lower scores toward each extreme. The scores on the Brace test are not quite so definitely related to the body

* The names in parentheses are inserts by the author, showing approximate comparisons.

build classes but the highest group mean score is for the *ectomorphic* types and the lowest for the *endomorphic* types. The Brace test requires a marked amount of flexibility and agility, known to go along with the *ectomorphic* types. In the gymnastic events there does not seem to be consistent difference between the extremes, possibly due to the wide variety of items in the gymnastic tests and the adaptability of the ectomorphs to these events. In the aquatic events the linear extremes do less well than the *mesomorphic* or *meso-endomorphic* types. No doubt some of the events require floating capacity and organic power that go along with the athletic and well nutrified groups.

The differences in the condition tests show that the flexibility of the linear men averages better than for the heavier types. The *mesomorphic* types are knit together with heavier ligaments and fat impedes bending in the trunk and shoulder tests. The differences are not consistent in posture, possibly due to the way posture was scored and normed. In this case ten aspects were averaged and the percentile rating for this average T-score determined. Further studies should show the posture scores averaged on each of the ten items for the various body type classifications (Chapter III, page 353).

Interesting differences are shown in the circulatory-respiratory scores which are in general agreement with the findings of Larimore.[55] The *ectomorphic* types have the lowest scores on the McCurdy-Larson test. While this test is made up of items other than blood pressure, no doubt the fact that blood pressure varies the same way with body build types is a principal element in the trend for the linear types to have lower scores in the circulatory-respiratory test. Larimore has shown that linear types (asthenic) average 106.8 mm. Hg. (males) and 105.7 (females) in systolic blood pressure; 63.3 (males) and 68.2 (females) in diastolic blood pressure. The hyposthenic (athletic) group averages higher in mean scores for both systolic and diastolic blood pressures, 116.3 (male) and 115.6 (female) in systolic pressure, 71.7 (male) and 72.3 (female) in diastolic blood pressure. This group falls between the asthenic and sthenic groups. The sthenic group gives the highest means for both blood pressures. The systolic pressures are 126.3 (male) and 118.4 (female), the diastolics 78.7 (males) and 73.4 (females). The sex differences are not significant, nor do the relations change appreciably when the types are separated into age groups by decades. The study was made on 417 factory workers.

CONCLUSIONS

1. Classifications according to constitutional type groupings provide a basic framework for the understanding of health and many types of physical fitness and athletic performances.

2. Health and physical guidance work in public schools, colleges, and private agencies should make use of the *somatotyping* proced-

TABLE VII

RELATIONSHIP OF BODY BUILD TO BODY MECHANICS AND PERFORMANCE TESTS (Class of 1939)

Body Build Classification (by Subjective Judgment using Sheldon's Criteria) Form BTS	No. Cases	Mean Age (Years)	Body Build Wt./Ht. (lbs./in.)	Body Build $Wt./Ht.^2$
Endomorphic	1	17.8	M = 2.45 (raw scores)	M = 3.67 (raw scores)
Endomorphic-Mesomorphic	4	19.4	M = 2.38 σ = .13 R = 2.19 to 2.52	M = 3.40 σ = .25 R = 3.05 to 3.70
Mesomorphic	20	20.1	M = 2.30 σ = .137 R = 2.13 to 2.65	M = 3.33 σ = .188 R = 3.09– to 3.77
Mesomorphic-Ectomorphic	56	19.6	M = 2.13 σ = .21 R = 1.72 to 2.67	M = 3.11 σ = .34 R = 2.00 to 3.80
Ectomorphic	9	19.4	M = 2.05 σ = .10 R = 1.89 to 2.20	M = 3.07 σ = 2.36 R = 2.78 to 3.42

TABLE VII (Continued)

RELATIONSHIP OF BODY BUILD TO BODY MECHANICS AND PERFORMANCE TESTS (Class of 1939)

	Normed Strength (Rogers' P.F.I.)	All-Round Athletic Ability (Cozen's Test)	Motor Ability (Brace Test)	Track and Field (Composite of Sprinting, Broad Jump, High Jump, and Shot Put)
Endormorphic	M = 61.5 (raw scores)	M = 308.6 (raw scores)	M = 40.0 (raw scores)	M = .6 (Average of T-Score Converted to percentile rating)
Endomorphic-Mesomorphic	M = 85.5 σ = 11.2 R = 70.1 to 97.0	M = 324.55 σ = 55.0 R = 269.3—404.7	M = 63.75 σ = 8.93 R = 50—75	M = 41.4 σ = 19.3 R = 24.5–74.5
Mesomorphic	M = 91.5 σ = 16.1 R = 69.2 to 134	M = 358.9 σ = 35.2 R = 304.9—417.7	M = 68.0 σ = 14.1 R = 40—90	M = 45.9 σ = 17.1 R = 21.8–71
Mesomorphic-Ectomorphic	M = 92.9 σ = 15.13 R = 65.5 to 144	M = 343.4 σ = 46.70 R = 202.5—433.6	M = 63.3 σ = 14.35 R = 35—90	M = 47.2 σ = 21.79 R = .6–84
Ectomorphic	M = 93.2 σ = 4.36 R = 66 to 110	M = 335 σ = 9.95 R = 291—385	M = 71.12 σ = 12.41 R = 45—90	M = 37.6 σ = 14.32 R = 19–66

* Skeletal
† Muscle
to Wei
‡ Fat In
Relationsh

Body Build Ht./$\sqrt[3]{\text{Wt.}}$	Bone Index*	Muscle Index†	Fat Index‡	Total Strength Rogers' Strength Index)
M = 12.12 (raw scores)	M = 29.6 (Average of T-Scores Converted to percentile)	M = 49.0 (Average of T-Scores Converted to percentile)	M = 91.7 (Average of T-Scores Converted to percentile)	M = 1352 (raw scores)
M = 12.25 σ = .13 R = 12.08 to 12.45	M = 39.47 σ = 10.6 R = 27—56.2	M = 47.52 σ = 16.1 R = 28.2—69	M = 52.22 σ = 17.8 R = 34.4—81.2	M = 1940 σ = 355 R = 1350 to 2248
M = 12.80 σ = .031 R = 12.20— to 13.40	M = 49.6 σ = 15.0 R = 1.1—72.7	M = 66.1 σ = 22.8 R = 13.4 to 97.5	M = 39.4 σ = 15.3 R = 16.1 to 71.5	M = 1994 σ = 363 R = 1559 to 2980
M = 13.0 σ = .40 R = 12.04 to 14.00	M = 47.3 σ = 13.27 R = 7.8—75.1	M = 42.4 σ = 24.64 R = 33—99.2	M = 44.3 σ = 21.06 R = 7.5—93.3	M = 1830 σ = 360 R = 1033 to 2932
M = 13.03 σ = .38 R = 12.40 to 13.70	M = 43.9 σ = 11.92 R = 27—69	M = 32.7 σ = 14.59 R = 16—61	M = 50.03 σ = 5.09 R = 41—56	M = 1697 σ = 313.9 R = 1136 to 2064

Gymnastic Ability (Composite of 7 Events)	Aquatic Ability (Composite of 7 Events)	Circulatory-Respiratory (McCurdy-Larson Organic Efficiency Test)	Flexibility (Average of Four Tests)	Posture (Average of Ten Measures)
M = 3.1 (Av. of T-Scores Converted to %ile Rating)	M = 1.7 (Av. of T-Scores Converted to %ile Rating)	M = 99.6 (Av. of T-Scores Converted to %ile Rating)	M = 39.0 (Av. of T-Scores Converted to %ile Rating)	M = 48.6 (Av. of T-Scores Converted to %ile Rating)
M = 54.35 σ = 14.3 R = 33.3—72—9	M = 44.45 σ = 9.41 R = 32.4—54.5	M = 39.97 σ = 34.8 R = 5.7—97.9	M = 40.37 σ = 8.7 R = 28.7—53.2	M = 46.3 σ = 11.7 R = 35.4—66
M = 52.7 σ = 19.0 R = 18.5—81.5	M = 47.3 σ = 23.0 R = 0—91.1	M = 58.8 σ = 27.5 R = 9.3—95.5	M = 44.3 σ = 15.1 R = 13.9—71.2	M = 51.5 σ = 11.6 R = 30.7—69.1
M = 48.4 σ = 15.65 R = 5.1—91.5	M = 36.2 σ = 12.35 R = 75.1	M = 63.9 σ = 27.43 R = 4.1—99.9	M = 45.4 σ = 14.33 R = 11.8—67.3	M = 49.4 σ = 8.91 R = 31.1—68.5
M = 50.66 σ = 5.38 R = 24—81	M = 24.23 σ = 19.44 R = .1—70.6	M = 39.4 σ = 23.41 R = 8—88	M = 45.3 σ = 9.38 R = 32—62	M = 50.03 σ = 5.09 R = 41—56

* Skeletal Index derived for Springfield College Men, Alfred Nordstrom, *An Analysis of Body Weight.*
† Muscle Index derived for Springfield College Men, John Squires, *An Analysis of Muscle Girths with Relationship to Weight, Nutrition, and Athletic Performance.*
‡ Fat Index derived for Springfield College Men, George Grover, *An Approximate Analysis of Adipose Tissue in Relationship to Nutrition, Condition, and Skeletal Size.*

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ures as a valuable basis for the understanding of individuals.

3. Continued research into these relations will yield much of value for the health and physical education field.

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CHAPTER II

Weight and Tissue Symmetry Analyses
(With Condition Profiles)

THOMAS K. CURETON, JR.*

WHAT is the best weight for an individual? Popular concepts of fitness always involve this question. The weight of the body is an excellent index of organic development. However, two individuals of the same skeletal size may weigh the same and still be vastly different in the proportions of muscle and fat, as well as in the size and density of the internal organs. One's weight, therefore, means very little unless it is differentiated into components of the various tissues. In general, an individual needs sufficient musculature to manipulate the bony skeleton and entire body weight efficiently. A moderate amount of adipose tissue is also needed for protection against sudden changes of temperature, as an energy reserve, and also as a cloak to retain the body heat. Too much adipose tissue is a sign of poor condition. Too little is dangerous.

GROSS TISSUE PROPORTIONS

The gross proportions of bone, muscle, and fat are studied from the point of view of symmetry. The proportions of bone and muscle should be fairly similar on a standard score or percentile scale (see Chart I). The need for a method of giving these relative or absolute proportions is great. Consider the type that has normal weight according to the age-height tables but excess adipose tissue and insufficient muscle. This type is usually in the "motor moron" class. Note the *acromegalic* with a great over-development of bone and insufficient muscle or fat to meet ordinary health and performance needs. The fat *mesomorph* is very much overweight because of large bones, much muscle, and also, perhaps, fat above average. Yet, this type of person may be active and powerful, whereas, the extreme *endomorph* is overweight and relatively helpless. It is all important to gain some insight into these proportions when making an appraisal of physical fitness. The amount of fat and the measured strength give important cues to fitness. In young men it may be demonstrated that strength tends to diminish as fat increases. The "fit" state coincides with high strength and moderate adipose tissue for the body type classification.

Trainers and conditioners depend upon weight charts as a guide to condition, since it is generally recognized that each person will have a best performance weight. With runners, this weight includes rela-

* The profile chart scales and the basic correlational evidence were derived from the studies of graduate students Alfred Nordstrom, George Grover, and John Squires, theses sponsored by the writer.

tively little fat but with swimmers much more fat may be tolerated because of the relatively slower movements in swimming and the aid which the fat gives to buoyancy. Sports differ and also the individual types differ. This is a field in which empirical observation has dominated along with the "feeling" of fitness recognized by each individual. Such judgments are far from being on a scientific basis. These relations should be fully understood and much more research is needed.

THE DANGER OF OBESITY

Deaver[11] summarizes the medical literature on obesity calling attention to its dangers, stressing the overload which fat puts upon the heart due to every pound of fat requiring about 4,500 ft. of blood vessels. Obesity calls for a great expansion of the capillary beds and nutritive requirements.

The Metropolitan Life Insurance Co.[38] reports that men who are 35 per cent or more above average weight for their age and height have a mortality rate of 1½ times that of the average men. Also, that when the abdominal girth is more than two inches greater than the chest girth at full expansion, the extra mortality is 50 per cent above the excess mortality associated with the overweight itself. Associated with the overweight and "bay window" types are unusually high incidences of high blood pressure, albuminuria, glycocuria, cerebral hemorrhages, angina pectoris, and Bright's disease. It is probable that the overweight *mesomorph* presents a vastly better health picture than the obese *endomorph*.[16] Weight analyses should differentiate at this point.

THE DANGER OF UNDERWEIGHT

The individual who is markedly underweight is subject to respiratory ailments including tuberculosis, bronchial catarrh, influenza, and colds. The underweight type is easily chilled and does not have the organic power of those with relatively more muscle and fat. When the adipose cloak (subcutaneous fat) is too thin, the body is susceptible to changes in temperature from the outside environment. Sudden chilling may lower the threshold of resistance so that frequent infection results. The underweight types frequently show marked signs of mal-nutrition, such as, dark circles under the eyes, pale mucous membranes, pot-belly, winged scapulae, hollows beneath clavicles, dull eyes and expression, and a worried anxious look. Associated health disabilities include conjunctivitis, keratitis, eczema, and rough skin. Most prominent are postural disorders due to lack of muscular energy to resist the gravity pull on the various segments.

THE METHODS OF APPRAISING WEIGHT

The deviations from the mean of a group may indicate very little for a particular person, unless the subjects in the group are of the same body build. There are several ways of appraising weight.

1. *Age-Height-Weight Tables.*—The tables usually used with adults

are the *Medico-Actuarial* Tables[37] but these tables were adopted in 1912 and were constructed from data involving subjects weighed in shoes and indoor clothes. They are undifferentiated for body build. Better tables exist for young men.

Thus, Cozens[10] reports an Age-Height-Weight table for entering college men based on 7389 cases, nude, measured at the University of California at Los Angeles. This table gives the probable error for each weight, showing the variability including 50 per cent of the cases.

Weight tables are usually found in books of *Applied Hygiene*, such as in Williams' text[57] or in *How to Live* by Fisher and Fisk.[17] Weight increases sharply within each year from 15 to 19 years for boys and then levels off to increase very gradually between 20 and 30 years, this being shown clearly in the Schwartz, Britten, and Thompson graph.[47]

The best tables for young men are probably those of Diehl[12] covering the heights and weights of American College men including 23,122 cases from 10 universities.

2. *Predicted Weight from Regression Equations.*—Many workers

TABLE I

HEIGHTS AND WEIGHTS OF COLLEGE MEN 16–21 YRS. (DIEHL)

Height	Mean Weight		S.D.		C.V.	No. Cases	Per Cent
49	70					1	.004
53	112.50	±3.71	7.78	±2.62	6.92	2	.01
54	110.00					1	.004
55	113.00	±4.07	13.51	±2.88	10.16	5	.02
56	128.75	±3.17	13.30	±2.24	10.33	8	.03
57	110.00	±4.27	19.99	±3.01	18.17	10	.04
58	122.94	±2.86	17.51	±2.03	14.24	17	.07
59	120.33	±3.73	21.42	±2.64	17.80	15	.06
60	128.50	±3.14	29.44	±2.22	22.91	40	.17
61	123.36	±1.62	19.69	±1.15	15.96	67	.29
62	117.70	±.82	14.87	±.58	12.64	150	.65
63	121.56	±.55	14.09	±.39	11.59	298	1.29
64	124.87	±.37	14.32	±.26	11.47	678	2.93
65	128.20	±.27	14.06	±.19	10.97	1201	5.19
66	132.11	±.21	14.12	±.15	10.69	2055	8.89
67	135.63	±.19	14.77	±.14	10.89	2722	11.77
68	139.29	±.17	15.30	±.12	10.98	3535	15.29
69	142.43	±.18	15.76	±.13	11.07	3487	15.08
70	146.03	±.19	15.78	±.13	10.81	3215	13.90
71	149.66	±.21	15.27	±.15	10.20	2437	10.54
72	152.97	±.29	16.89	±.20	11.04	1582	6.84
73	157.71	±.40	17.86	±.29	11.32	892	3.86
74	162.19	±.61	18.49	±.43	11.40	420	1.82
75	164.62	±.99	19.94	±.70	12.11	183	.79
76	170.09	±1.65	18.67	±1.17	10.98	58	.25
77	168.26	±2.77	19.69	±1.96	11.70	23	.10
78	169.17	±3.16	16.21	±2.23	9.58	12	.05
79	152.50	±5.33	11.18	±3.77	7.33	2	.01
80	173.33	±15.13	38.84	±10.69	22.41	3	.01
81	197.50	±11.80	24.75	±8.35	12.53	2	.01
82	160.00					1	.004
Mean 68.68	±.01 141.65	±.08	18.11	±.06	12.79	23,122	99.72

have shown that height is not a good predictor of weight and that other skeletal or body measurements correlate more highly with weight. Taylor[52] was one of the first to question the accuracy of the tables when in 1922 he wrote on "The Great Underweight Delusion." He hit a new note by insisting that only those with similar builds could be compared.

Studies which attempted to predict weight from bases other than height were made by Gray and Parmenter,[23] Johnson,[30] and Highsmith

WEIGHT PREDICTION EQUATIONS

McCloy[34]	.2359 × Height (cm.)	= ———	Actual Wt. = ———
	.9641 × Chest Girth (cm.)	= ———	
	1.1400 × Hip Width BiC. (cm.)	= ———	Predicted
	2.4800 × Knee Width (cm.)	= ———	Weight = ———
	Sum of All	= ———	
	Less Constant	−112.8	Residual = ———
	Predicted Weight in Kg.	= ———	
Quimby[44]	Multiplier × Height (in.)	= ———	Actual Wt. = ———
	Multiplier × Shoulder Width over acromion processes (in.)	= ———	Predicted
	Multiplier × Chest Width (in.)	= ———	Weight = ———
	Multiplier × Chest Depth (in.)	= ———	
	Multiplier × Hip Width (in.) (over Iliac Crests)	= ———	Residual = ———
R = .736 to .892	Sum of All	= ———	
	Less Constant	———	
	Predicted Weight (lbs.)	= ———	

MULTIPLIERS AND CONSTANTS FOR QUIMBY'S EQUATIONS

Age Group	Height	Sh. W.	Chest W.	Chest D.	Hip W.	Constant
16¼	1.82	4.19	5.38	7.99	5.70	−225.39
16¾	1.03	4.70	5.52	8.82	5.10	−189.61
17½	2.14	3.71	5.93	5.49	2.59	−199.45
18½	1.91	4.89	8.86	7.80	1.22	−229.39
19½	2.18	4.26	7.16	8.20	.612	−217.37
20½	2.16	6.28	8.08	7.50	1.30	−257.49
21½	1.08	5.25	8.37	9.09	5.70	−229.33
22½	2.23	.489	13.40	9.43	−1.34	−214.15

Note: For ages above 22½ use the last set of constants.

Allen[1]	1.2032 × Chest Girth Expanded (in.)	———	Actual Wt. = ———
	1.168 × Biceps Girth Contracted (in.)	———	Predicted
	2.6535 × Hip Width Between Iliac Crests (cm.)	———	Weight = ———
	Sum of All	———	Residual = ———
	Less Constant	−19.006	
	Predicted Weight (lbs.)	———	
Nordstrom and Cureton[40]	11.202 × Chest Breadth (in.)	= ———	Actual Wt. = ———
	12.567 × Ankle Girth (in.)	= ———	
	6.715 × Chest Depth (in.)	= ———	Predicted
	4.438 × Hip Width (in.)	= ———	Weight = ———
	1.658 × Height (in.)	= ———	
R = .939	Sum of All	= ———	Residual = ———
P.E. (Est. Wt.)	Less Constant	−317.20	
= 3.77 lbs.	Predicted Weight in lbs.	= ———	

and Sorensen,[28] and McCloy[35] published weight standards for the individual, meaning that the weight was normed to the person's own measurements rather than those of the whole group. There were many criticisms of the height-weight tables, among them being Franzen,[19] Turner,[56] Boillin,[7] Pryor and Stolz,[41,42,43] and Quimby.[44] The most recent is by Allen.[1] Practically all these propose weight prediction equations based upon skeletal measurements. McCloy, Nordstrom, Quimby, and Allen developed the equations shown on page 334.

RESIDUALS AS BASIS OF DIAGNOSIS

All the prediction equations assume that the residuals (differences between the actual and the predicted weight) are valid measures upon which to diagnose underweight or overweight. However, with large errors of estimate this is a very doubtful procedure.* Study of some of these residuals show that they are worthless as a basis for determining overweight or underweight. With the Nordstrom-Cureton *Skeletal Build Index* equation, it was decided that the method of profile analysis was not only more accurate but indicated some of the principal reasons why the individual is underweight or overweight. It is all important to have a *differential* analysis of weight.

TISSUE SYMMETRY ANALYSIS

Cause of the Deviation (Overweight or Underweight) Is Basic.—Prediction of weight indicates that the items in the equation *and all items in correlational association with these* account for the weight to the extent indicated by the equation. The multiple *R* and error of estimate tests are applied to check the efficiency of the equations. The fundamental thing is to know *why* an individual is overweight or underweight. There is no very exact way of doing this. In at least half of the cases it cannot be told with any degree of accuracy from prediction equations based on skeletal measures. If the case falls within the range of the probable error of estimate, there is relatively little deviation of the case from the straight line norm through the data. If the case falls off the normative line, there is nothing in the equation to tell *why*. The residual is an error of prediction due to lack of reliability and to imperfectly measured or unincluded factors. There is no sure way of telling what any particular residual means. In any case, it should be clear that the individual is still being compared to the group norm (the

* It should be kept in mind that no regression equation can produce an exact fit to an individual case even though the individual's measures are substituted into the equation. The multipliers are derived on the basis of group relationships. The equation represents a straight line which fits the data as closely as possible. With the regression line plotted upon the field of data, the perpendicular distance from any one case to the line represents the residual for the case. This is an error of prediction, due to the imperfect fit of the line to that point. The significance of the residual in terms of adipose tissue, bony build, and muscular development should be determined. This usually cannot be done unless measurements are available of those factors and, even then, the residuals correlate so low with these factors that little use can be made of the results in diagnosis of the needs of the person.

straight line) and not to his own body build. More exact methods would use the particular body build (somatotype) for the individual. It is also helpful to have measures which will show the relative proportions of skeletal build, muscle strength, muscular development, adipose tissue, and check list ratings. In studying the significance of the residuals in the results of Nordstrom,[40] Grover,[24] and Squires,[50] the writer is convinced that the residuals are of little value. A profile comparison of the various measures of bone, muscle, strength, and fat is a great help. This is called *Tissue Symmetry Appraisal.*

PROCEDURE FOR TISSUE SYMMETRY APPRAISAL

To carry out the tissue symmetry appraisal, follow these steps:

1. Measure the skeletal build by means of the Nordstrom-Cureton skeletal build index equation items. Compute the index, using the computing form. Use routine "A" (p. 337) including the computing table. Plot this value on the profile chart (p. 340), line "A."

2. Measure the adipose tissue by means of the Grover-Cureton adipose tissue index equation items. Compute the index, using the computing form. Use routine "B" including the computing table. Plot this value on the profile chart, line "B."

COMPUTATIONAL FORM

OBJECTIVE APPRAISAL OF NUTRITION AND PREDICTION OF WEIGHT

Name..... Age..... Sex..... Nationality.....

Skeletal Index[1] ("A")*

Measure	*Factor* †
.....Chest Breadth	.....
.....Ankle Girth, Av.	.....
.....Height	.....
.....Chest Depth, Normal	.....
.....Hip Width	.....
Total	.....
Constant	−317.20
Skeletal Index Score	.....

Muscle Girth Index[3] ("C")

Measure	*Factor*
.....Gluteal Girth	.....
.....Calf Girth, Av.	.....
Total	.....
Constant	−119.02
Muscle Girth Index Score	.....

Adipose Index[2] ("B")

Measure	*Factor*
.....Cheeks, Av.	.....
.....Abdomen	.....
.....Hips, Av.	.....
.....Gluteals, Av.	.....
.....Front Thigh, Av.	.....
.....Rear Thigh, Av.	.....
Constant	22.25
Adipose Index Score	.....

Weight Prediction Using Above Indices ("D")

Skeletal Index Score ..... Factor.....
Adipose Index Score ..... Factor.....
Muscle Index Score ..... Factor.....
Constant −18.07
Predicted Weight ..... lbs.
Actual Weight.....Minus Predicted Weight..... = ...lbs. (residual)

* Use Scoring Chart "A" to find factor.
† Factor is the actual measure multiplied by the beta value.

3. Measure the gross muscle girths by means of the Squires-Cureton muscle development index equation items. Compute the index, using the computing form. Use routine "C" including the computing table. Plot this value on the profile chart, line "C."

4. Determine the Rogers Strength Index and locate this on the profile chart. Use Rogers' technique for the strength test. (Note that the S.I. and not the P.F.I. is used.)

5. Compute the predicted weight using routine "D" with the computing tables. Determine the residual (unpredicted part of weight due to errors and unincluded part not accounted for in the measures).

COMPUTATION TABLE FOR SKELETAL INDEX—ROUTINE "A"

Chest Breadth (X_1)		Ankle Girth (X_2)		Chest Depth (X_3)	
Measure × 11.2 =	Factor	Measure × 12.57 =	Factor	Measure × 6.72 =	Factor
13.0	145.6	10.2	128.21	10.0	67.20
12.8	143.36	10.0	125.70	9.8	65.85
12.6	141.12	9.8	123.19	9.6	64.51
12.4	138.88	9.6	120.67	9.4	63.17
12.2	136.64	9.4	118.16	9.2	61.82
12.0	134.40	9.2	115.64	9.0	60.48
11.8	132.16	9.0	113.13	8.8	59.14
11.6	129.92	8.8	110.62	8.6	57.79
11.4	127.68	8.6	108.10	8.4	56.45
11.2	125.44	8.4	105.59	8.2	55.10
11.0	123.20	8.2	103.07	8.0	53.76
10.8	120.96	8.0	100.56	7.8	52.42
10.6	118.72	7.8	98.05	7.6	51.07
10.4	116.48	7.6	95.53	7.4	49.73
10.2	114.24	7.4	93.02	7.2	48.38
10.0	112.00	7.2	90.50	7.0	47.04
		7.0	87.99	6.8	45.70
				6.6	44.35
				6.4	43.01
				6.2	41.66
				6.0	40.32

Hip Width (X_4)		Height (X_5)	
Measure × 4.44 =	Factor	Measure × 1.66 =	Factor
15.0	16.60	75	124.50
14.8	65.71	74	122.84
14.6	64.82	73	121.18
14.4	63.94	72	119.52
14.2	63.05	71	117.80
14.0	62.16	70	116.20
13.8	61.27	69	114.54
13.6	60.38	68	112.88
13.4	59.50	67	111.22
13.2	58.61	66	109.56
13.0	57.72	65	107.90
12.8	56.83	64	106.24
12.6	55.94	63	104.58
12.4	55.06	62	102.92
12.2	54.17	61	101.26
12.0	53.28	60	99.6
11.8	52.39		
11.6	51.50		
11.4	50.62		

Prediction equation for Nordstrom-Cureton Skeletal Index:

$$\tilde{X}_0 = 11.202\,X_1 + 12.567\,X_2 + 6.715\,X_3 + 4.438\,X_4 + 1.658\,X_5 - 317.204$$

$R = .939$ P.E. (Est. X_0) = 3.766 lbs.

6. Examine the graphic record for evidence of symmetry or asymmetry with these assumptions:

a) That the reference item to which the others are compared is the skeletal index.

b) That the score for muscular development should be aligned vertically with the skeletal index score for the individual to be symmetrically developed.

c) That the Strength Index should be vertically aligned with the skeletal index and the muscular development index for symmetrical development.

d) That a moderate amount of adipose tissue should be indicated with a score lower on the scale than for the muscle girth and strength scores. When the adipose tissue is higher, the condition is not desirable for "condition."

e) That the study of these "patterns" or profile graphs will show clearly

COMPUTATION TABLE FOR ADIPOSE INDEX—ROUTINE "B"

Cheeks (X_1)		Abdomen (X_2)		Hips (X_3)	
Measure × 1.023 =	Factor	Measure × 1.706 =	Factor	Measure × 1.66 =	Factor
25	25.58	28	30.13	26	43.16
24	24.55	27	29.05	25	41.50
23	23.53	26	27.98	24	39.84
22	22.51	25	26.90	23	38.18
21	21.48	24	25.82	22	36.52
20	20.46	23	24.75	21	34.86
19	19.44	22	23.67	20	33.20
18	18.41	21	22.60	19	31.54
17	17.39	20	21.52	18	29.88
16	16.37	19	20.44	17	28.22
15	15.35	18	19.37	16	26.56
14	14.32	17	18.29	15	24.90
13	13.30	16	17.22	14	23.24
12	12.28	15	16.14	13	21.58
11	11.25	14	15.06	12	19.92
10	10.23	13	13.49	11	18.26
		12	12.91	10	16.60

Gluteals (X_4)		Front Thigh (X_5)		Rear Thigh (X_6)	
Measure × 1.065 =	Factor	Measure × 1.504 =	Factor	Measure × 1.002 =	Factor
47	50.06	40	60.16	40	40.08
45	47.93	38	57.15	38	38.08
43	45.80	36	54.14	36	36.07
41	43.67	34	51.14	34	34.07
39	41.54	32	48.13	32	32.06
37	39.41	40	45.12	30	30.06
35	37.28	28	42.11	28	28.06
33	35.15	26	39.10	26	26.05
31	33.02	24	36.10	24	24.05
29	30.89	22	33.09	22	22.04
27	28.76	20	30.08	20	20.04
25	26.63	18	27.07	18	18.04
23	24.50	16	24.06	16	16.03
21	22.37	14	21.06	14	14.03
19	20.24	12	18.05	12	12.02
17	18.11	10	15.04	10	10.02
15	15.98				

Grover-Cureton Adipose Index

$\tilde{X}_0 = 1.023X_1 + 1.706X_2 + 1.660X_3 + 1.065X_4 + 1.504X_5 + 1.002X_6 - 22.245$

$R_0 = .976$ Sigma (Est. X_0) = 6.20 (Franzen's Units)

P.E. (Est. X_0) = 4.18 (Franzen's Units)

COMPUTATION TABLE FOR MUSCULAR DEVELOPMENT INDEX—ROUTINE "C"

Gluteal Muscle Girth			Calf Muscle Girth		
Measure	× 4.30 =	Factor	Measure	× 7.74 =	Factor
45		193.5	17.1		132.35
44		189.2	16.8		130.03
43		184.9	16.5		127.71
42		180.6	16.2		125.39
41		176.3	15.9		123.07
40		172.0	15.6		120.74
39		167.7	15.3		118.42
38		163.4	15.0		116.10
37		159.1	14.7		113.78
36		154.8	14.4		111.46
35		150.5	14.1		109.13
34		146.2	13.8		106.81
33		141.9	13.5		104.49
32		137.6	13.2		102.17
31		133.3	12.9		99.85
30		129.0	12.6		97.52
			12.3		95.20
			12.0		92.88

Squires-Cureton Muscular Development Index

$\tilde{X}_0 = 4.30\,X_1 + 7.74\,X_2 - 119.02$

Wt. = 4.30 (Gluteal Girth) + 7.74 (Av. Calf Girth) − 119.02

$R_0 = .8177$

Sigma (Est. X_0) = 9.42 lbs.

P. E. (Est. X_0) = 6.35 lbs.

COMPUTATION TABLE FOR PREDICTED WEIGHT—ROUTINE "D"

Total Adipose Index			Skeletal Size Index			Muscle Girth Index		
Measure	× .128 =	Factor	Measure	× .473 =	Factor	Measure	× .493 =	Factor
230		29.44	200		94.60	200		98.60
225		28.80	195		62.24	195		96.14
220		28.16	190		89.87	190		93.67
215		27.52	185		87.51	185		91.21
210		26.88	180		85.14	180		88.74
205		26.24	175		82.78	175		86.28
200		25.60	170		80.41	170		83.81
195		24.96	165		78.05	165		81.35
190		24.32	160		75.68	160		78.88
185		23.68	155		73.32	155		76.42
180		23.04	150		70.95	150		73.95
175		22.40	145		68.59	145		71.49
170		21.76	140		66.22	140		69.02
165		21.12	135		63.86	135		66.56
160		20.48	130		61.49	130		64.09
155		19.84	125		59.13	125		61.63
150		19.20	120		56.76	120		59.16
145		18.56	115		54.40	115		56.70
140		17.92	110		52.03	110		54.23
135		17.28	105		49.67			
130		16.64	100		47.30			
125		16.00						
120		15.36						

$\tilde{X}_0 = .128\,X_1 + .473\,X_2 + .493\,X_3 - 18.07$

Weight = .128 (Total Adipose Index) + .473 (Skeletal Size Index) + .493 (Muscle Girth Index) − 18.07

$R_0 = .937$

Sigma (Est. X_0) = 5.62 lbs.

P.E. (Est. X_0) = 3.79 lbs.

what the person needs for conditioning in terms of gross muscular development or fat reduction.

The method has the advantage of being quite objective, provides a permanent record, is motivational in that the result is graphic and is easily understood in counseling. It serves as a screen test to isolate those who are markedly asymmetrical for follow-up with the physician and physical director.

SCORING CHART FOR TISSUE SYMMETRY ANALYSIS

PROFILE CHART I

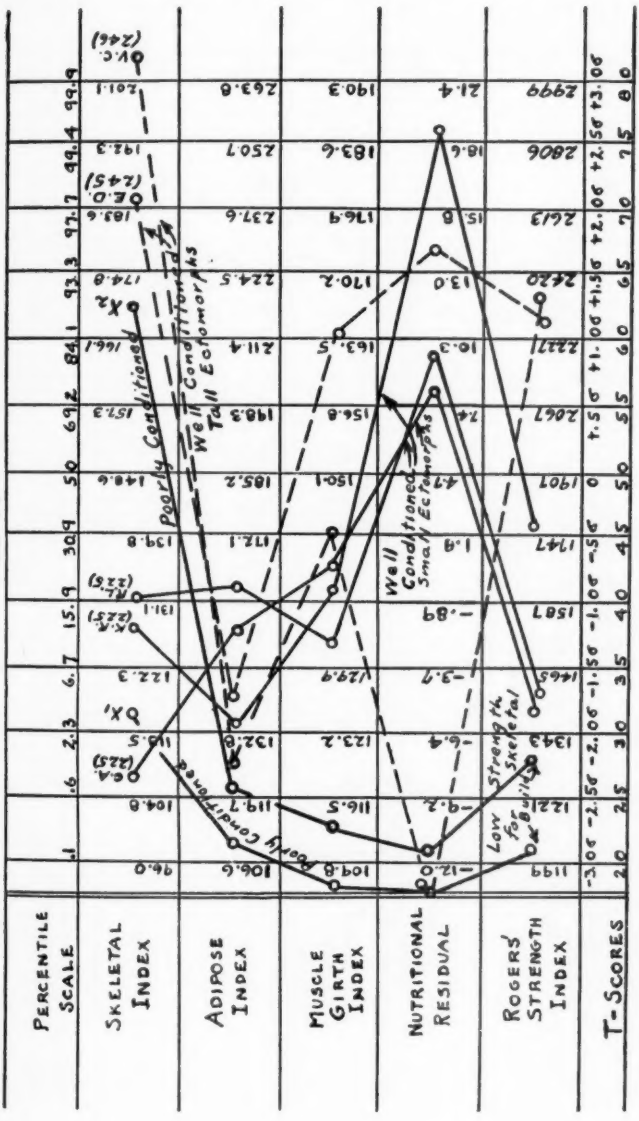
	Percentile Rating Scale												
	.1	.6	2.3	6.7	15.9	30.9	50.0	69.2	84.1	93.3	97.7	99.4	99.9
Skeletal Index "A"	96.03	104.79	113.54	122.30	131.05	139.81	148.56	157.31	166.07	174.82	183.58	192.33	201.09
Total Adipose Index "B"	106.56	119.66	132.76	195.86	158.96	172.06	185.16	198.26	211.36	224.46	237.56	250.66	263.76
Muscle Girth Index "C"	109.81	116.52	123.23	129.94	136.65	143.36	150.07	156.78	163.49	170.20	176.91	183.62	190.33
Nutritional Residuals	−11.99	− 9.24	− 6.44	− 3.66	− .89	1.89	4.66	7.43	10.26	13.03	15.81	18.58	21.36
Rogers' Strength Index	1199	1221	1343	1465	1587	1747	1907	2067	2227	2420	2613	2806	2999
-3σ -2.5σ -2σ -1.5σ -1σ $-.5\sigma$ 0 $+.5\sigma$ $+.1\sigma$ $+1.5\sigma$ $+2\sigma$ $+2.5\sigma$ $+3\sigma$													
T-Scores	20	25	30	35	40	45	50	55	60	65	70	75	80

PATTERNS OF CONDITION FROM PROFILE CHART

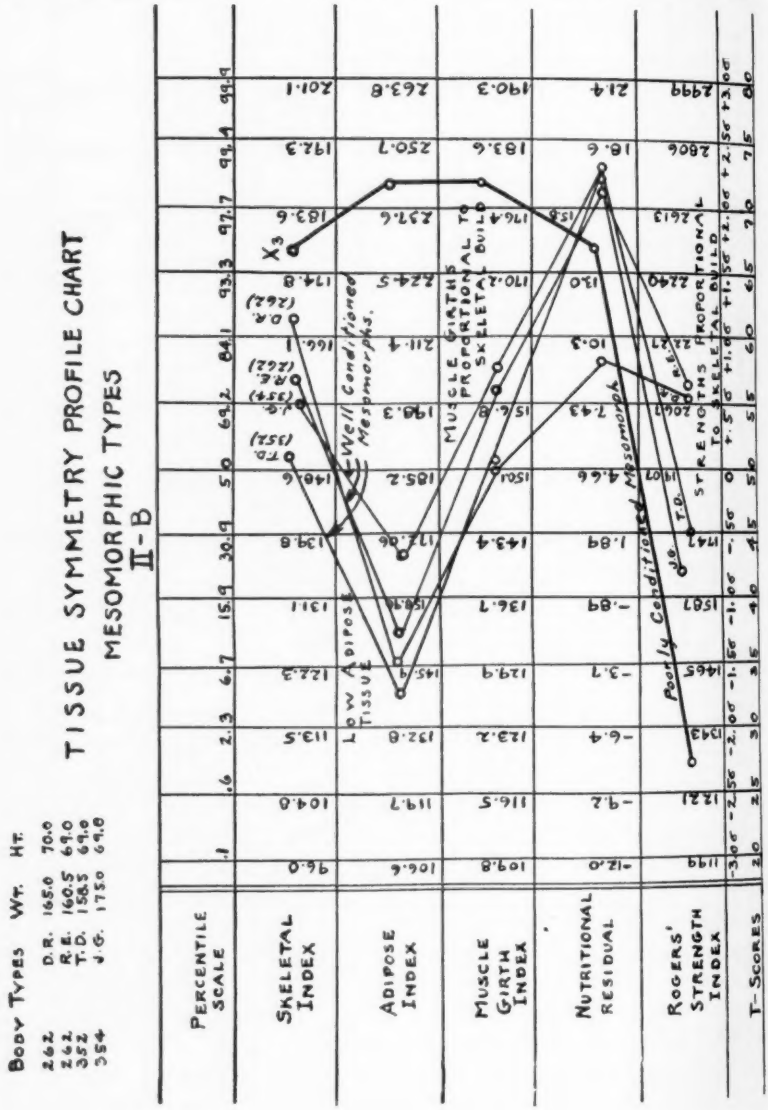
Interpreting Condition from Profile Chart.—Profile Charts II-A, II-B, and II-C show the results of plotting some typical indices. In general, the strength and muscle indices should not be lower on the scale than the skeletal index for the same case. This type of condition implies that there is sufficient muscular development and strength to operate the skeleton with speed and power, or to sustain its alignment under postural control without fatiguing quickly. The well-conditioned types have adipose tissue ratings lower than the muscular and strength ratings, relatively.

Referring to Chart II-A, Ectomorphic Types, cases A.C. (225), K.R. (225), R.L. (225) are medium to light weight ectomorphs in fairly good condition. The muscle girth ratings are higher than the skeletal index ratings. The nutritional residuals are also higher than

the skeletal index ratings, indicating roughly that the men weigh more than their predicted weight. The residuals here are thought to be meaningful because of the cases being sifted out according to type which eliminates some of the error of prediction. The strength indices are as high as the skeletal index scores, aligned approximately below. As contrasts, observe the hypothetical cases X_1 and X_2, which seem to be poorly developed cases with low adipose ratings, low muscle girth rat-

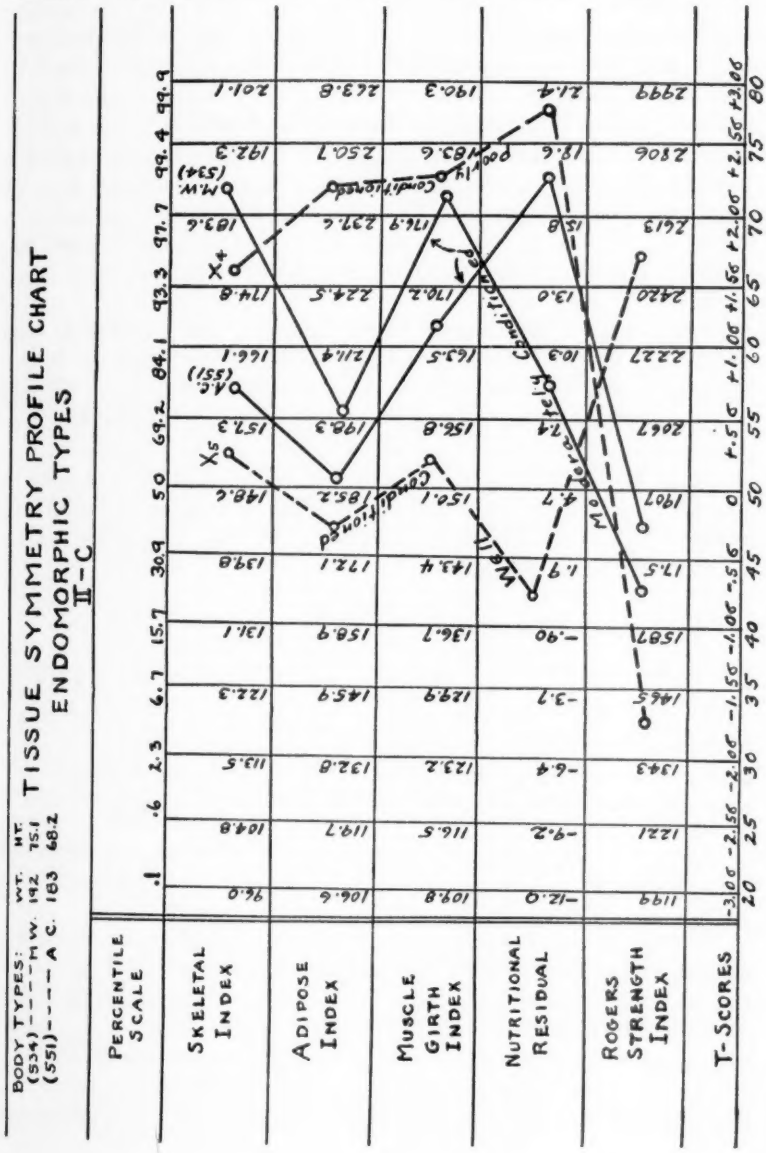


ings, negative residuals, and very low strength ratings. Two very tall ectomorphs are shown in dotted lines. The skeletal index ratings are very high, the adipose scores are very low, the muscle girth and strength scores are much higher but still not up the scale far enough to be aligned with the skeletal indices. Case V.C. (246) is very much underweight with an extremely low negative residual but has surprisingly good strength for the type. Case E.D. (245) is extremely tall, with very low



adipose score but has surprisingly high scores for muscle girth and strength. This case would not be judged underweight by the residual.

Chart II-B shows five mesomorphs, four with very satisfactory condition and one hypothetical case out of condition. In cases T.D. (352), J.G. (354) R.E. (262), and D.R. (262), the men have relatively low adipose scores, proportionately aligned muscle girths, and relatively high



residuals, indicating that all of them are above their predicted skeletal weight. Cases D.R. and R.E. have very satisfactory strength scores but J.G. and T.D. are somewhat low. Case X_3 is out of condition with an adipose rating higher than the other measures except the muscle girth score, which is also high possibly because of fat infiltration into the muscles. The case is overweight 14 pounds by the residual estimate and has exceedingly low strength.

Chart II-C shows four endomorphic types, two of them hypothetical. These types are rare in the available data. Cases A.C. and M.W. have big skeletons, adipose above averge, bulky muscles, and are fairly strong in actual strengths. The cases are overweight by the residuals, case A.C. by 17 pounds. The cases are only moderately conditioned in strength. The two hypothetical cases show opposite types from the standpoint of condition. Case X_4 is fat, with fatty muscles, grossly overweight by 20 pounds, and has very low strength. Case X_5 is well conditioned, approximately normal in weight, with relatively high muscle girths and strength.

There is a slight tendency for the strength test scores to be lower as the fat measurements get higher ($r = -.119$) with the Rogers' S.I. and $-.404$ with the P.F.I.). Athletic ability has a slight tendency to diminish as adipose increases ($r = -.202$). These data do not include extreme endomorphic or ectomorphic-endomorphic types low in strength. The correlations would be higher if such extremes were included. Low skeletal and muscular indices are associated with poor athletic ability, as are high adipose indices. An interesting example is shown of this in chinning:

TABLE II

BODY BUILD AND CHINNING ABILITY

	No. of Chins (Average)
Low Skeletal, Strength, and Muscular Indices (Ectomorphs).....	4.7–5.3
Medial Skeletal, Strength, and Muscular Indices (Meso-Ectomorphs)	8.8
High Skeletal, Strength, and Muscular Indices (Mesomorphs).....	10.0

Thus, these patterns of differential weight analysis connect up with the body type groupings. Further studies along this line should yield some very valuable results.

Within the range of these data, the *Adipose Index* is not significantly related to the McCurdy-Larson Organic Efficiency Index ($r = .056$), the track endurance die-off ratio ($r = .113$), or the swimming endurance die-off ratio ($r = -.064$). Extreme types are, of course, handicapped in these events. The *Adipose Index* correlates significantly low ($r = .286$) with Quimby's weight prediction residual and higher with the Medico-Actuarial table residuals ($r = .498$). The results mean that

the table residuals reflect some changes in fat but it would be better to have estimates of fat directly in terms of caliper measurements.

Strength and Skeletal Index Scores are fairly strongly related with the correlations going as high as .70. However, the Muscle Index is not a very good estimate of strength because the correlation between these two factors is .314, holding adipose out by the partial correlation technique.

In the weight prediction equation, predicting weight from the skeletal index, muscle girth index, and adipose index, the residuals are not significantly correlated with the P.F.I. (.018), the McCurdy-Larson test (.091), the Cozens test (.092), track and field ability (.053), gymnastic ability (.093), aquatic ability (.122), Brace test (—.058), or Burpee test (.035). This means that the residuals are insignificant as a means of determining condition of the type which would vary with these types of performances.

CONCLUSIONS

1. The Age-Height-Weight tables do not give objective evidence as to the cause of overweight or underweight; neither do the prediction equation residuals indicate the differential causes of overweight or underweight. The residuals make a hazardous base for a diagnosis.

2. The Tissue Symmetry Analysis by means of the *profile chart* makes a differential analysis of weight of great value, highly useful in planning a conditioning program for an individual.

3. Weight and skeletal index correlate .851, weight and the adipose index .488, weight and the muscle girth index .840. These proportions are approximately the same as the bone, fat, and muscle anatomical quotas estimated directly in the flesh. All three items give a multiple *R* for predicting weight of .937 with a probable error of estimate of 3.79 pounds. Adding the S.I. raises the *R* to .952.

4. Further research should correlate the patterns of condition with health variables. They may also be related to types of athletic performances. Studies should be made to determine how much change can be made in the factors of skeletal build index, muscle girth index, adipose index, and strength index as a result of varying amounts and types of exercise.

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CHAPTER III

Bodily Posture as an Indicator of Fitness

By THOMAS K. CURETON, JR.

POSTURE, as an aspect of physical fitness, has an enormous popular and scientific literature. Postural "slump" indicates fatigue or poor condition and may be viewed as a barometer of muscular tone. The keen body mechanics observer may detect tell-tale signs of deep seated disability or incapacity for dynamic healthful living through a postural appraisal, noting evidences of lassitude, ptosis, unbalanced segments liable to produce strain and irritation of important nerves, and the mental concomitants of poor posture.

Schwartz[79] * has contributed a resume of the available literature of posture. Goldthwait [40] lists 341 references to the medical literature of posture, representing a selection of materials which relate to his book *Body Mechanics*.† Popular adaptations of these sources are found regularly in the current newspapers and periodicals. Some play up the theme that *youth* is reflected in posture, marked by graceful poise while standing, sitting, walking, running, or exercising. The relationships of posture to health and fitness are repeatedly inferred in titles, such as, "He Stoops to Conquer and Loses—How Man is Penalizing Himself in the Race for Good Health and Long Life by Incorrect Posture—Slouching at Work and Play, Breathing Incorrectly and Cramping Vital Organs Until the Capacity to Resist Disease is Impaired,"[39] "You're Only as Young as Your Back,"[61] "How You May be Making Yourself a Cripple,"[33] "Learning How to Market Their Beauty."[32] Hundreds of critical thinkers have come to see that posture is an important concomitant of fitness, associated both as a result of ill health and low energy state, as well as a causal factor in poor circulation and nervous irritation. Precise proof of these relations only lists partially completed research, much of it applicable to case studies of an extreme nature. Fundamental truths in this area of health and physical education work need to be summarized.

Posture is a phase of body mechanics, defined by the orthopedic subcommittee of the Hoover White House Conference[70] as "the *mechanical correlation of the various systems of the body with special reference to the skeletal, muscular, and visceral systems and their neurological associations.*"

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* Superior figures refer to numbered bibliography at end of article.

† Many of the references in the Schwartz and Goldthwait bibliographies are not reproduced in this article owing to lack of space.

Meredith [67] gives the following reasons for good posture:

1. For comfort and endurance in maintaining the upright posture, and for skill in other bodily acts.
2. For the health of the bones, joints, and muscles.
3. For the sake of the organs and general health.
4. For its esthetic value.
5. For its psychological effect.
6. For the impression it makes upon others.

Instructors commonly stress "head high," "chin in," "neck back," "abdomen flat," "feet straight," "flattened back," "relaxed shoulders," "easy knees," "weight on outside of feet." Examiners note the degree to which "poke-neck," "slumped chest," "kyphosis," "lordosis," "protuberant abdomen," "scoliosis," "high shoulders," "bow-legs," "knock-knees," "pronated feet," and "toed-out feet" are present. The assumption is that these manifestations of structural mal-alignment and ptoses are symptomatic and in turn causal of other disorders, establishing a vicious cycle leading to poor health.

POSTURE AND HEALTH

Many workers have studied and written about the relations of posture and health. A few of these will be briefly summarized to indicate the nature of the relationship, considering the three categories of (1) Mental, (2) Physiological, (3) Morphological:

Mental Relationships of Posture.—Cowell [20] points out that one's mental attitude toward life, comrades, work, and self is strongly colored by his state of health. It is maintained that physical poise is related to mental poise, motor attitude to mental attitude. A state of happiness and well being is indicated by facial expression, muscular tonicity, increased peripheral circulation, and bodily posture. Conversely, the hanging limbs, the flaccid facial and trunk muscles of the "down and out" individual or the chronic dyspeptic are well known. Attractive and efficient posture has long been associated with desirable personality traits. "Attention" may be considered "tension" of the muscles, in which muscular tone is increased. A well conditioned body makes possible good posture, the emotional concomitants of which might well be self-respect, pride, self-confidence, and courage. Weak muscles, poor posture, and weak will are likely to go hand in hand.

Burnham [13] supports the relationship of posture as a condition of efficient brain activity and especially suggests that posture may condition definite emotional tendencies and habits of mental activity. Kretschmer [56] emphasizes the inter-play and correlation of physique, posture, and character. Sherrington [82] found bodily posture dependent upon the muscular tonus acquired through the activity of the proprioceptive system, thus giving sensation of and perception of posture.

Kempf [53] states that there is a close interplay between the sensory and motor nerve circuits. The postural tonus of muscle is influenced by the autonomic sensori-motor apparatus, the muscle serving both as a receptor and effector. Sweigard [85] stresses the fact that each individual is a bundle of motor habits; that all posture, relaxation, and directed movement are results of training the neuromuscular system, and that as long as one can think, motor habits can be changed. All students of the physiological and psychological aspects of posture place great importance upon *conditioned reflexes* acquired as a result of postural training.

Deaver's study [27] relating the A, B, C, D, silhouette grades of posture according to the Harvard scheme, with intelligence ($r = .014$), grade points ($r = .002$), personality ratings ($r = -.008$), auditory-sensory reaction ($r = .055$) on 343 normal college students gives insignificant findings. Likewise, Gunkler's study at Berea College [47] relating body mechanics grades to scholastic standing ($r = .068$) and to intelligence ($r = .049$) shows a similar relationship. These studies have not measured a number of the aspects described above, nor are the body mechanics measures or statistical procedures good enough to bring out the relationships of muscle tone to intelligence or personality traits. The relationships which are undoubtedly present in extreme postural cases are lost in unselective statistical studies. The case study technique must be more fully applied to this area of work.

Organic Condition (Physiological) Relationships.—Biologists, such as Jennings, Cannon, and Fulton, give proof that the behavior of animal organisms at any given moment depends upon their physiological state, meaning the active physico-chemical process. The works by Goldthwait [40] and Dickson [29] may be cited as sources which give good summaries of the relations between posture and health, stressing anatomical and physiological relationships. Goldthwait [40, 41, 42, 43] emphasizes keeping the chest free to breathe with a relatively full excursion of the diaphragm in all postures so as to guarantee good circulation. His materials clearly show that this is impossible with a slumped chest, the circulation to vital organs being retarded because of poor breathing and mechanical blockage. The great importance of head posture is stressed because the *suspensory* ligament attached to the cervical vertebrae draws up on the attached heart, diaphragm, and attached viscera. This requires constant cultivation of tonus in the posterior neck and upper back muscles. Ulcered stomach and postural diabetes are traced to poor posture, as are gasteroptosis and enteroptosis. All long-time students of this problem including Kellogg,[52] Dickson [29] and Mosher,[69] describe the harmful effects to health of visceroptosis, the abnormal falling downward of the abdominal viscera. These cases in the extreme show lack of stamina in ordinary activities, are usually constipated and complain of malaise, migraine, headache, offensive breath, and anorexia. They are commonly ner-

vously exhausted and irritable people who suffer from insomnia and inability to concentrate.

Reynolds and Lovett [73] investigated low back pain in women and concluded that it is associated with marked lordosis, flat back, or with diseases and displacements of the pelvic viscera.

Parvy (ref. 29, p. 89) shows the proof of strain and fatigue in the upright position, usually associated with lordosis, causing *orthostatic albuminaria*, the night urine being free from albumin. The condition disappears in some cases with elimination of the lordosis. This is thought to be associated with the disturbance of the sympathetic ganglia, or renal veins which lie close to the lumbar spine. Some authorities think that the albumin is the result of toxemia due to fatigue. The types which show this disorder are usually extreme ectomorphs, pale, anemic, and underweight. They complain of palpitation of the heart and very frequently show skin disorders related to nutritional disturbances, such as, eczema.

Ciriax [21] points out associations between dorso-cervical posture deficiencies and cardiac disease. Carnett and Bates [15] point out that the most common cause of neuralgic pain and tenderness, especially in individuals under 30 years of age, is excessive lordosis which is thought to pinch the spinal nerves as they pass through the intervertebral foramina. This tenderness or pain may occur anywhere in the body but is fairly common in the scalp, abnominal wall, and feet. The pain has been shown to disappear in certain cases when the lordosis is eliminated.

Intestinal stasis has been suggested by numerous writers as a causative factor in arthritis. The investigations by Smith, Loring, Swain, Goldthwait, Osgood, and Pemberton show that gastro-intestinal disturbances must certainly be considered as a possible cause in the chronic poly-arthritis with multiple joint involvement and periarticular enlargements. (In these cases there is imbalance in the ileocaecal flora.)[40,29]

Still, it must be admitted that most illnesses are due to infections of a specific germinal nature and the relations to posture are not very direct. It is uncertain that functional inefficiency directly affects the incidence of such diseases.

Morphological Relationships.—The relationships of body build to health, and the close connection of constitutional type to heredity, suggest at once a strong relationship between posture and health, since it is granted that posture is likewise influenced to some extent by heredity. Posture needs to be appraised and interpreted with consideration of its relationships to body build of a permanent constitutional nature.

Man's posture has gradually evolved from that of his quadruped ancestors. Many books describe this comparative anatomy, including those by Bowen and McKenzie,[8] Clevenger,[17] Baker,[4] and Morton.[68] Many of the body structures are primarily designed for use in the

horizontal position, as analysis of the anatamo-mechanical arrangements in the spine, veins, the appendix, the breathing apparatus, and the feet indicate. The lumbar curve of the spine and the arches of the feet have developed to meet the needs of the erect position and bipedal locomotion.

The type of bony structure determines, to quite some extent, the posture of the body as a whole or of any particular segment. Rogers [74, 75] emphasizes the *long* view of posture, stressing the dominance of hereditary morphology:

"No evidence whatsoever exists that the style of carriage we happen to have been born with can be changed to a straighter model. There is no evidence of a relation of mentality or morality to carriage unless it be from some underlying cause affecting both mental and physical condition.

"There is no evidence whatsoever that posture is essentially influenced either by general or by special posture exercises—there is ample evidence that, like all our other features, physical and mental, posture is an *inherited* trait bound up with the complicated physique handed down through millions of years and not to be tampered with lightly for artistic purposes."

Studies by McCloy,[62] Howland,[49] and Boynton [9] lend support to the idea of morphological dominance due to heredity. McCloy concluded that wider vertebrae give straighter spines and narrow thoracic vertebrae give greater relative kyphosis. The Howland and Boynton X-ray studies of the pelves of women show that the relatively high, shallow pelvis gives a hyper-flat back or the extreme opposite of lordosis. The deep type of pelvis is the type that gives a marked lordosis. From two pelvic measurements lordosis can be predicted to a multiple *R* of .80.

Damany [26] and others have shown that the angular measurement of the femoral head in its relation to the shaft and to the acetabulum show wide differences between people of the same age. These relations affect lordosis and the degree to which the feet toe out or toe in. A standard position would require standardization of the angular relations in femoral torsion, which is impossible. Some people are not structurally adapted to standing or walking with the feet straight ahead, even though external mechanics might suggest better application of force from the straight ahead foot.

Bryant's 300 autopsy records [12] show the extreme ectomorphic type is subject to ilial stasis and intestinal adhesions. Bean, in observing 1002 patients and 311 autopsies concluded that in this type the stomach was small, long, J-shaped, and far to the left. The liver is small, low, vertical, and far to the right; the intestines are small and of short calibre. The colon is long with a low hepatic flexure and high splenic flexure, with a definitely low placed transverse colon and long mesentery. The arrangement of these organs obviously affects their internal posture.

Schwartz, Britten, and Thompson[78] (p. 47) found no appreciable relationship between the type of build (as judged by the relations between height, weight, and abdominal circumference) and posture as they measured it. This study should not be considered final on this problem because the indices used for body build do not reflect many of the specific relations which exist, nor do the measures of posture indicate the specific items of posture accurately enough to settle the issue.

Table I shows the results of classifying the class of 1944 at Springfield College on ten items of posture according to five body build groupings:

TABLE I

TEN ASPECTS OF POSTURE ACCORDING TO BODY BUILD CLASSIFICATIONS
(Comparison of Mean Values)

Items	Units	Ectomorphs N = 14	Mesomorphic-Ectomorphs N = 69	Mesomorphs N = 34	Mesomorphic-Endomorphs N = 5	Endomorphs N = 0
Head posture	%ile	50.0	70.0	60.0	50.0	
Shoulder thrust	%ile	79.0	77.1	70.3	57.7	
Kellogg's chest ratio ..	%ile	36.9	41.6	46.4	50.0	
Kyphosis	%ile	86.7	86.6	86.6	87.9	
Lordosis	%ile	23.0	30.9	41.5	49.0	
Abdominal ptosis .....%ile		79.0	85.0	89.0	70.0	
Hip thrust	%ile	80.0	72.0	85.0	72.0	
Knee thrust	%ile	68.0	71.0	80.0	79.0	
Center of gravity	%ile	37.1	50.5	57.6	47.8	

The above table shows that head posture averages best for the meso-ectomorphs and mesomorphs and then drops off sharply at each extreme. The ecotomorphs give the best shoulder ratings with progressively lower scores on all other groups. The meso-endomorphs have the best chest ratio with the scores progressively lower as the men get more slender. On kyphosis the differences are insignificant between all groups. The ectomorphs have the greatest lordosis and the scores get better as the body build gets stockier. The mesomorphs have less abdominal ptosis than the other groups and the meso-endomorphic class, the most. The hip thrust scores are not consistent in trend. The ectomorphs show a slight trend toward hyper-extension of the knees but the differences are not great. The ectomorphs have the poorest center of gravity ratings with the scores improving in the mesomorph groups but lowering again in endomorphy. The ectomorphs and meso-ectomorphs have the best average head and shoulder posture. The mesomorphs and meso-endomorphs have the best posture on other items. This makes rather a confusing picture and shows why the composite posture scores on a T-score or percentile basis are not very meaningful. Best posture is not at the same end of the scale for all

items. The items which show the greatest range of differences between the means are in order (1) Lordosis, (2) Forward Shoulders, (3) Center of Gravity, (4) Head Posture, and (5) Abdominal Posture. These items are most affected by constitutional build, the other items less so with kyphosis least of all. These are only gross relationships which need to be studied much more specifically as Morton has studied the feet.

THE MEASUREMENT OF POSTURE

Cureton,[23] Cureton and Wickens,[25] and Gunby[24] have critically reviewed the literature on the methods of measuring anteroposterior posture covering a great variety of methods. Many of these are defective due to the measures being made over the soft flesh, influenced by compensations in the body segments, or based upon debatable assumptions, such as, the straighter the spine, the better the spine; or measures made outside the body are valid for inside interpretations. This has been an area of confusion and one is literally astounded to see the great amount of work that has been done on posture measurements. There is no doubt about two points which would seem to justify posture measurements: (1) that the individual differences can be measured reliably on at least ten important aspects of posture, and (2) that these measurements and photographs are highly motivating to the subjects.

The methods may be grouped into two principal approaches (including only normal standing posture):

I. Subjective judgment by experts, holding in mind criteria of good and poor posture.

II. Objective photography or measurement of posture, scaling the scores on specific items or combining the scores into a composite or average rating.

SUBJECTIVE JUDGMENT OF POSTURE BY EXPERTS

The subject is asked to stand so that a plumb bob string falls in alignment with the center of the instep (Illustration I-A). The body is then inspected in the anteroposterior plane to note ten aspects of posture with each graded on a 0–10 scale:

Very marked defects needing immediate referral to an orthopedic surgeon ..... 0–2 Points
(Fourth degree, marked 4)

Marked defect sufficient to be assigned to corrective class, pending inspection by orthopedic surgeon ..... 3–4 Points
(Third degree, marked 3)

Mild defect sufficient to be assigned to corrective class for conditioning and educational work ..... 5–6 Points
(Second degree, marked 2)

Slight defect, judged to be mostly educational need, listed for advisement ..... 7–8 Points
(First degree, marked 1)

No defect, perfect posture ..... 9–10 Points
(Marked 0)

FORM SP SUBJECTIVE POSTURAL ANALYSIS

Name ..... Age..... Height..... Weight.....

Address ..... Class..... Somatotype.....

Item	Specifications for Rating	Scores 0–10	Scores Degree
I. Head posture	Note angulation of imaginary line from center of base of neck through tragus of the ear.		
II. Shoulder posture	Note position of shoulder with relation to the base of the neck and Sterno-Clavicular notch.		
III. Chest posture	Note chest carriage in relation to body as a whole, the slope of the Manubrium, sub-costal angle, slope of ribs.		
IV. Abdominal posture	Note relative alignment of abdomen to chest, fist test to abdomen for control and development of muscles, amount of fat over muscles.		
V. Upper back	Note kyphotic curve; note after asking subject to flatten it; note while subject is bent over from the waist.		
VI. Lower back	Note lordosis curve; note after asking subject to flatten it; note while subject is bent over from the waist.		
VII. Pelvis	Note type, mark slope of Iliac Crest with flesh pencil; note tilt of pelvic basin as a whole.		
VIII. Knees	Note position of joint at rear of knee; note angulation of Tibia to plumb line.		
IX. General alignment	Note the body as a whole with respect to alignment with the plumb line in place at center of instep.		
X. Bilateral symmetry	Observe from rear the symmetry of head, shoulders, spine, hips, legs. Note amount of unevenness if present. Turn subject so that plum line falls down center of back. Measure lateral deviation of spine (scoliosis) and observe with subject bent over.		
	Total Score		

Notations

Item ....

Item ....

Item ....

Examiner .....

OBJECTIVE MEASUREMENT OF POSTURE

A comparison of the *subjective* judgment of posture with the *objective* measurement of posture shows that the objective method is very much better in reliability, approximately four times as good.[24] Certain items of great importance are not susceptible of judgment, such as the Center of Gravity item. Chart I shows that the subjective scores (total scores) are skewed to the right toward higher grades, which might be quite true for Springfield College men. The *objective* measurement of

thirteen items composed by averaging the T-scores gives a much more normal distribution. The most important problem is the *meaning* of the total scores, either subjective or objective. Study of these gives great doubt about their interpretation or usefulness. In some items, like the spinal curves, best posture is represented by moderate curvatures inter-

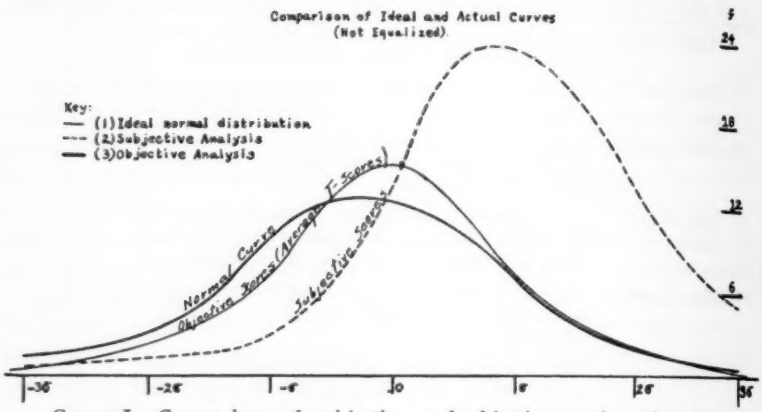


CHART I. Comparison of subjective and objective scoring of posture.

mediate in the scale of individual differences (see Chart II). This is true for most items but with head posture, the most retracted neck is usually put at the top of the scale, and the most forward carriage of the center of gravity, likewise. Items very much dominated by body build, such as, the lordosis, shoulders, and center of gravity items are averaged with items which are not very much influenced by heredity but are more the result of educated postural reflexes or conscious control, such as, the knee and hip thrusts, chest posture, and kyphosis.

No good system exists for weighting the items scientifically. The result is a total score made up of an average or sum of very incommeasurable items which cannot be interpreted in such an over-simplified system. The only solution to be advanced at this time is that each item must be separately measured and interpreted for itself, without summing or averaging the scores. This permits the extreme cases to be dealt with on the basis of their needs. It isn't possible to tell from a total score what item is poor, the separate measurements must be observed. The total score is useful only to facilitate simplification in dealing with the public or for over-simplified statistical solutions. The writer believes that most of the difficulty in validating posture items has come from lumping the items into an uninterpretable score and correlating this with other things.

TYPES OF OBJECTIVE MEASUREMENTS

Kellogg[52] has described the procedure of measuring the chest posture by means of a *ratio,* shown as item No. 4 on Illustration III. Aside

CHART II

PHYSICAL NORMS FOR SPRINGFIELD COLLEGE MEN

OBJECTIVE POSTURE ANALYSIS

NAME_____

ADDRESS_____

ITEMS	TECHNIQUE OF MEASUREMENT: Instrument	Specifications	SUBJECTS MEASURES	NO. OF CASES	PERCENTILE RATING SCALE .1	.6	1.2	2.3	4.0	6.7	10.6	15.9	22.7	30.9	40.1	50	59.9	69.2	77.3	84.1	89.4	93.3	96.0	97.7	98.8	99.4	99.9	PERC
1. FORE NECK	Silhouett, protractor, dividers.	Angle between two lines: (1) 7th. cervical thru' tragus, (2) Horizontal line thru' 7th. cervical.*	°	644			33.4	36.6	40.8	44.0	47.2		50.4		53.6		56.8		60.0		63.2		66.4		69.6	72.8		
2. SHOULDER THRUST	Silhouett, vernier callipers, ruler.	Mean horizontal distance between two lines: (1) Vertical thru' 7th. cervical. (2) Vertical tangent to front head of the humerus.	mm.	382	9.0	8.2	7.3	6.5	5.6		4.9		4.2		3.5		2.8		2.1		1.4		.78		0			
3. GOLDTHWAIT'S INDEX	Cloth tape with Gulick clip.	Maximum chest girth plus minimum chest girth divided by 2 = Normal. Deviation of actual chest girth from normal.	in.	308	-2.5	-2.1	-1.8	-1.45	-1.1		-.75		-.4		-.05		.3		.65		1.0		1.35		1.7		
4. KELLOGG'S CHEST RATIO	Protractor, dividers.	Ratio of two angles: Anterior angle divided by posterior angle.		497	.11	.27	.43	.59	.75		.95		1.11		1.27		1.43		1.70		1.97		2.24		2.80		
5. KYPHOSIS	Silhouettograph Conformateur apparatus, line and rule.	Maximum distance between a line, thru' 7th. cervical and inflection point, and maximum convexity of curve.*	mm.	504	2.8	2.6	2.38	2.16	1.94		1.72		1.50		1.28		1.06		.84		.62		.40		.18		
6. LORDOSIS		Maximum distance between line thru' two inflection points and maximum concavity of curve.*	mm.	502	2.3	2.08	1.85	1.62	1.39		1.20		1.02		.84		.66		.48		.30		.15		0		
7. ABDOMINAL PTOSIS	Protractor and rule.	Angle between two lines: (1) Vertical thru' Xyphoid process (2) Xyphoid thru' most protuberant point of lower abdomen. Deviation from vertical.*	°	677	13.2	11.4	9.6	7.8	6.0		4.2		2.4		-.6		-1.2		-3.0		-4.8		-6.6		-8.4		
8. HIP THRUST	Protractor and rule.	Angle between two lines: (1) Vertical thru' malleoli point (2) Malleoli point thru' great trochanter point.*	°	676	9.8	8.7	7.6	6.5	5.4		4.3		3.2		2.1		1.0		-.1		-1.2		-2.3		-3.4		
9. KNEE THRUST	Protractor and rule.	Angle between two lines: (1) Vertical thru' malleoli point (2) Malleoli point thru' front tip of head of tibia.*	°	533	.7	2.3	3.9	5.5	7.1		8.7		10.3		11.9		13.5		15.1		16.7		18.3		19.9		
10. BIG TOE ANGLE	Scholl's Pedograph print and protractor.	Angle between two lines: (1) Center of tip of big toe to center of back of heel (2) Center of tip of big toe thru' mean center of points bisecting big toe.	°	1147	21.8	19.7	17.6	15.5	13.4		11.3		9.2		7.1		5.0		3.8		2.6		1.3		0		
11. ARCH ANGLE		Angle between two lines: (1) From distal end of first metatarsal bone to inside of heel tangentially (2) From point 1 above to junction of long and transverse arches.[1]	°	1105	10.43	15.28	21.57	27.08	32.63		38.19		43.73		49.28		54.83		60.38		65.93		71.48		77.03		
12. SCAPHOID DEVIATION	Promation Ruler.	Lateral deviation of scaphoid measured from tangential line to inside edge of foot. Express as + or - (in or out) from reference line.	mm.	288	1.52	1.31	1.10	.89	.68		.47		.26		.05		-.16		-.38		-.59		-.80		-1.01		
13. CENTER OF GRAVITY	Balance Scales and board.	Cureton, T.K. & Wickens, S. "The C.of G. of the Human Body in the A-P Plane and its Relation to Posture, Physical Fitness and Athletic Ability" Res...Supp.,Vol.5, No.2,May 1934.	cm.	660	-2.0	-1.05	.10	1.2	2.6		3.5		4.7		5.9		6.8		7.7		8.9		9.6		11.0		
					-3 σ		-2½ σ		-2 σ		-1½ σ		-1 σ		-½ σ		0		+½ σ		+1 σ		+1½ σ		+2 σ		+2½ σ	+3 σ
					20				30				40				50				60				70			80

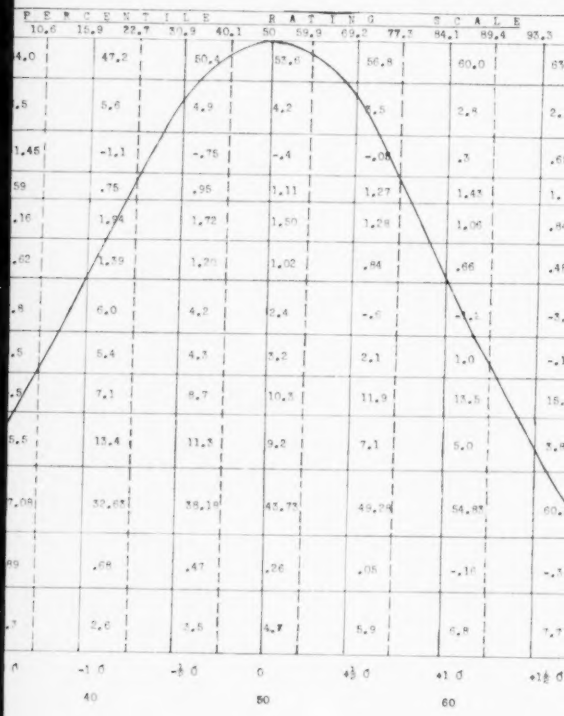
*Cureton, T.K., Wickens, J.S. and Elder, H.P. "Reliability and Objectivity of the Springfield Postural Measurements" Research Quarterly Supp., Vol. VI, No.2, May, 1935, pp. 81-92.

1 Cureton, T.K. "The Validity of Footprints as a Measure of the Vertical Height of the Arch and Functional Efficiency of the Foot" ibid. pp. 70-80.

CHART II

CAL NORMS FOR SPRINGFIELD COLLEGE

OBJECTIVE POSTURE ANALYSIS



LLEGE MEN

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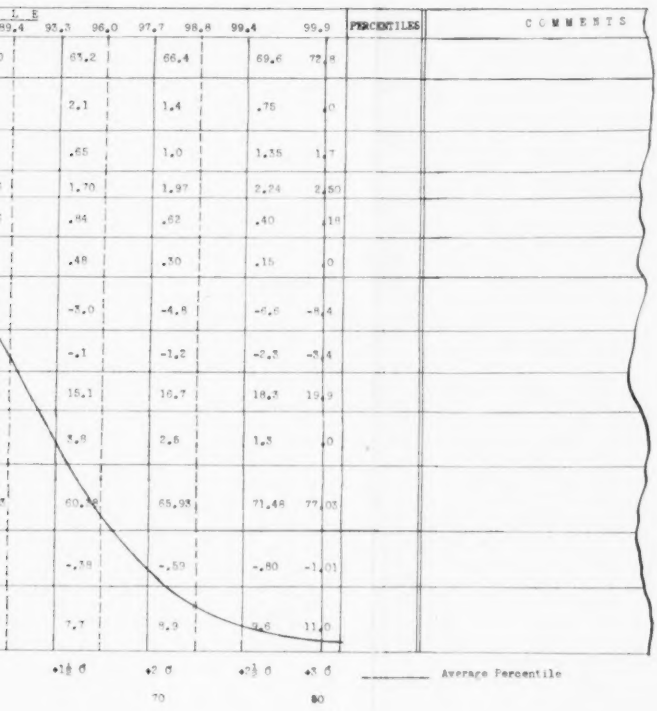

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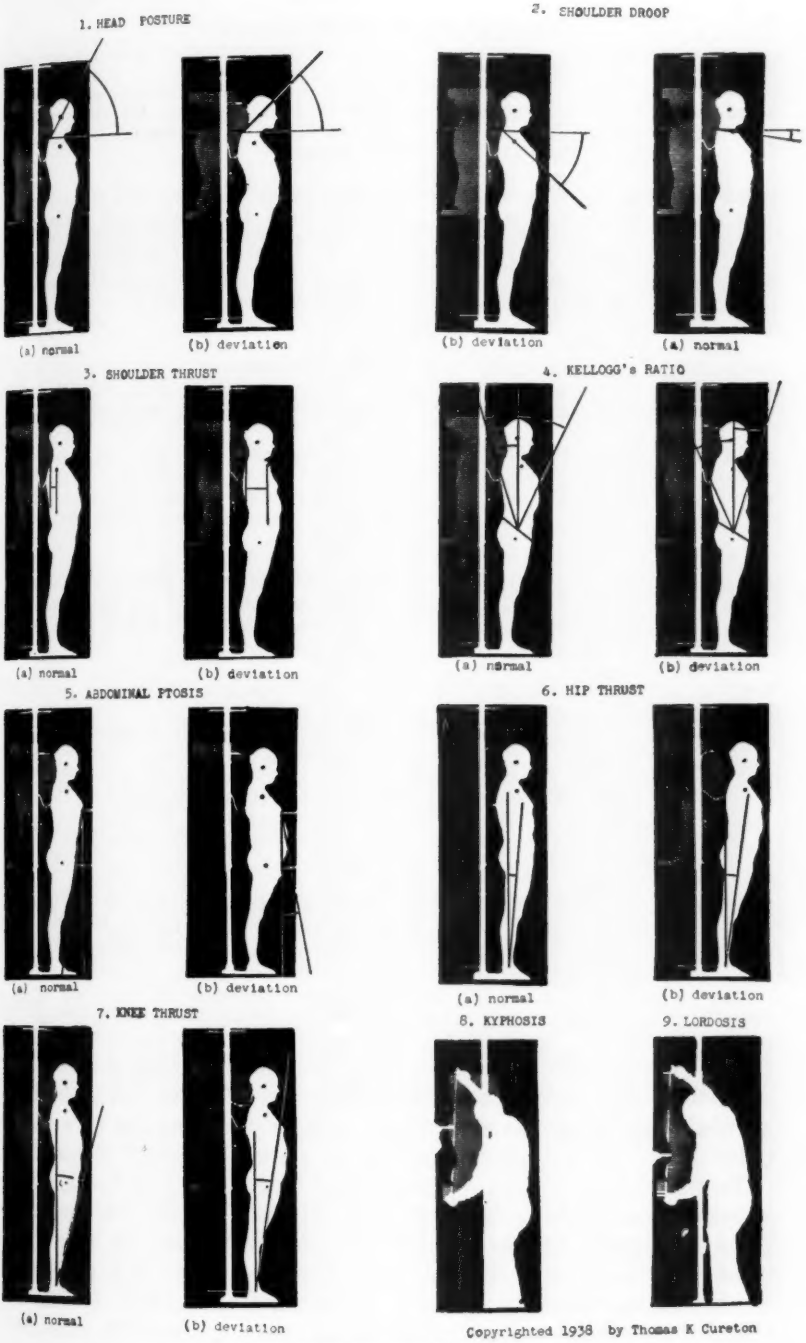

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ILLUSTRATION III.

TECHNIQUES OF MEASUREMENT*

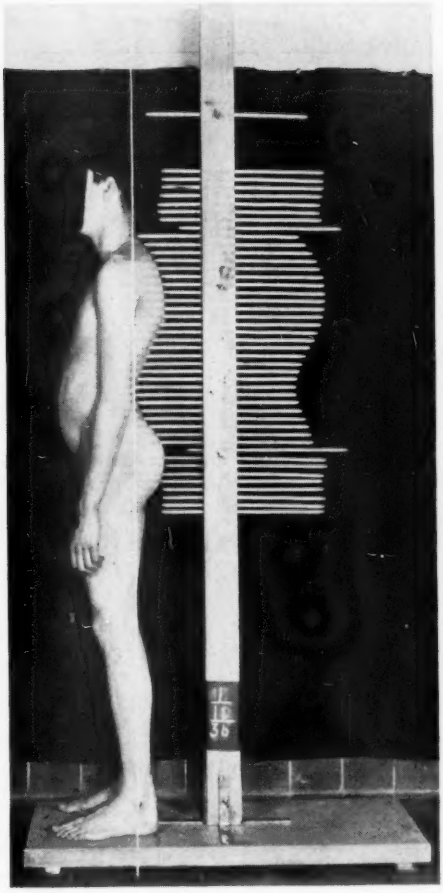
Items	Instruments	Specifications
Head posture (See Ill. III, 1)	Silhouette Protractor Dividers	Angle between two lines: (1) 7th cervical through tragus, (2) horizontal line through 7th cervical.
Shoulder droop (See Ill. III, 2)	Silhouette Protractor Dividers	Angle between two lines: (1) 7th cervical through head of humerus, (2) horizontal line through 7th cervical.
Kellogg's chest ratio (See Ill. III, 4)	Protractor Dividers	Ratio of two angles: anterior angle divided by the posterior angle.
Shoulder thrust (See Ill. III, 3)	Silhouette Vernier Calipers Ruler	Mean horizontal distance between two lines: (1) vertical through 7th cervical, (2) vertical tangent to head of humerus.
Abdominal ptosis (See Ill. III, 5)	Protractor Dividers Ruler	Angle between two lines: (1) vertical through Xyphoid process, (2) from Xyphoid process through most protuberant point of lower abdomen. Deviation from vertical.
Hip thrust (See Ill. III, 6)	Dividers Protractor Ruler	Angle between two lines: (1) vertical through malleoli point, (2) from malleoli point through great trochanter point. Deviation from vertical.
Knee thrust (See Ill. III, 7)	Protractor Ruler	Angle between two lines: (1) vertical through malleoli point, (2) from malleoli point through front tip of tibia. Deviation from vertical.
Kyphosis (See Ill. III, 8)	Silhouettograph Conformateur Apparatus Line and Rule	Maximum distance between line through 7th cervical and inflection point and maximum convexity of curve formed by tip of rods.
Lordosis (See Ill. III, 9)		Maximum distance between line, through two inflection points and maximum concavity of curve formed by the tips of rods.

* T. K. Cureton, J. S. Wickens, and H. P. Elder, "Reliability and Objectivity of the Springfield Postural Measurements," RESEARCH QUARTERLY SUPP., 6:81–92 (May 1935).

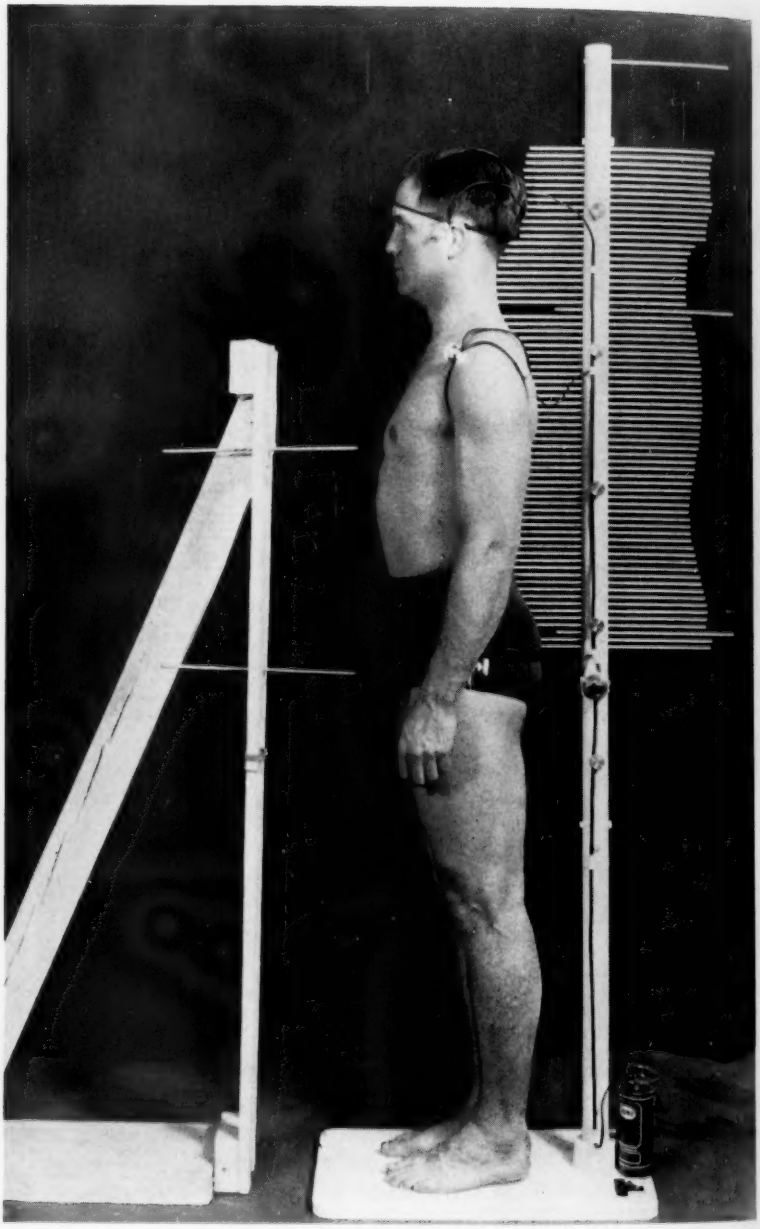
from Kellogg's work, four systems may be mentioned from a variety of methods of scaling silhouettes or photographs. MacEwan and Howe,[65] at Wellesley College, have published a method making use of a four-point scale and aluminum pointers to show the spinal curvatures (Illustration I-A). Cureton, Wickens, and Elder [23, 24, 25] devised a series of measurements shown in Illustrations III and IV which have been in use at Springfield College and with certain modifications at Yale University.[90, 91] Schwartz, Britten, and Thompson [78] (p. 13) published a series of measurements in the U. S. Public Health Dept., *Studies in Physical Development and Posture*. Illustrations IIa and IIb show the

ILLUSTRATION I.

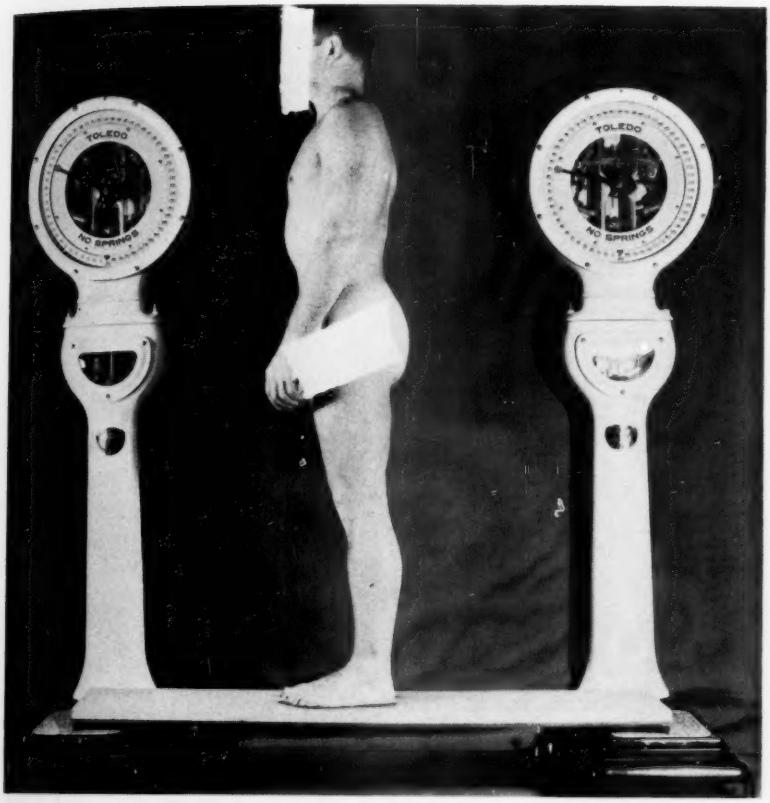
IA
Plumb line and MacEwan aluminum pointers in place



Wooden Conformateur



Above, ILLUSTRATION IIa: the conformateur. On opposite page, ILLUSTRATION IIb: upper photo shows the center of gravity equipment, lower photo the bank of lights and camera in place.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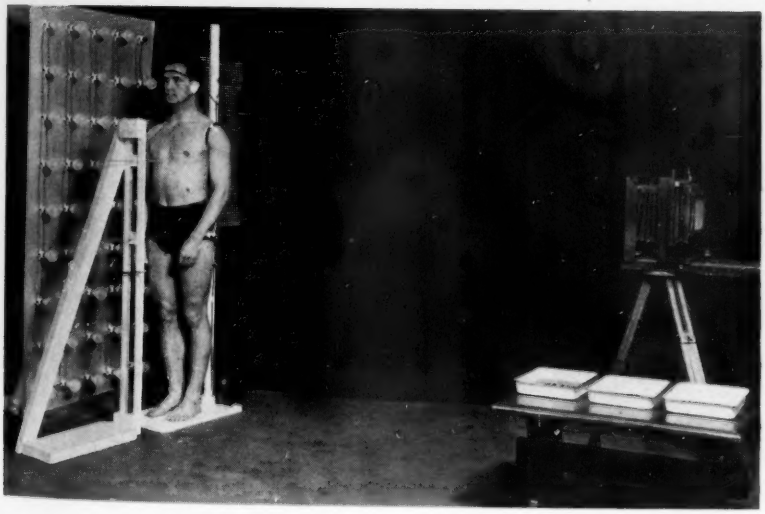

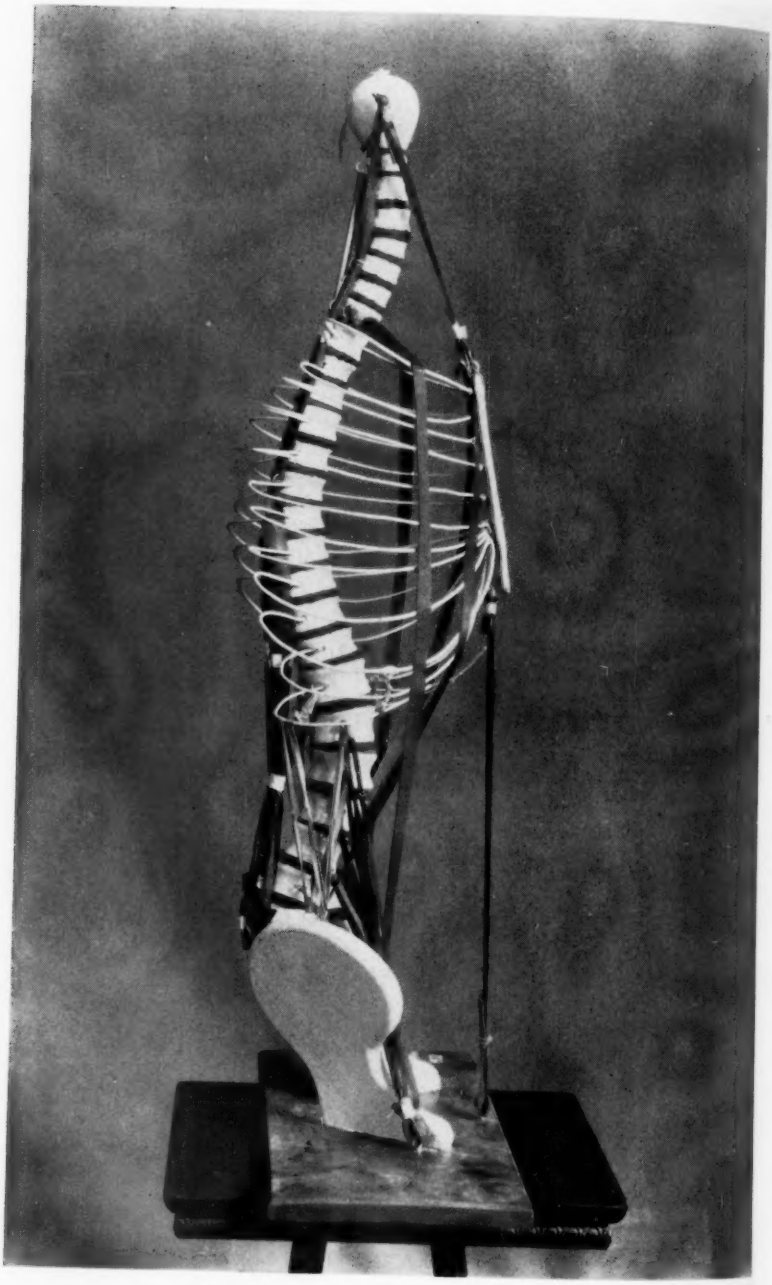

ILLUSTRATION V. Elastic pull of muscles

Cureton-Gunby Conformateur and the Cureton-Wickens Center of Gravity equipment. The conformateur equipment is used in conjunction with the Silhouette scheme devised by Norman Fradd, at Harvard University.[36] Complete procedure and tables to facilitate computation of the center of gravity have been published and are not reproduced here.[25] This test correlates as high as —.60 with kyphosis measurements, .75 with the Rogers P.F.I., .51 with the Rogers S. I., and .490

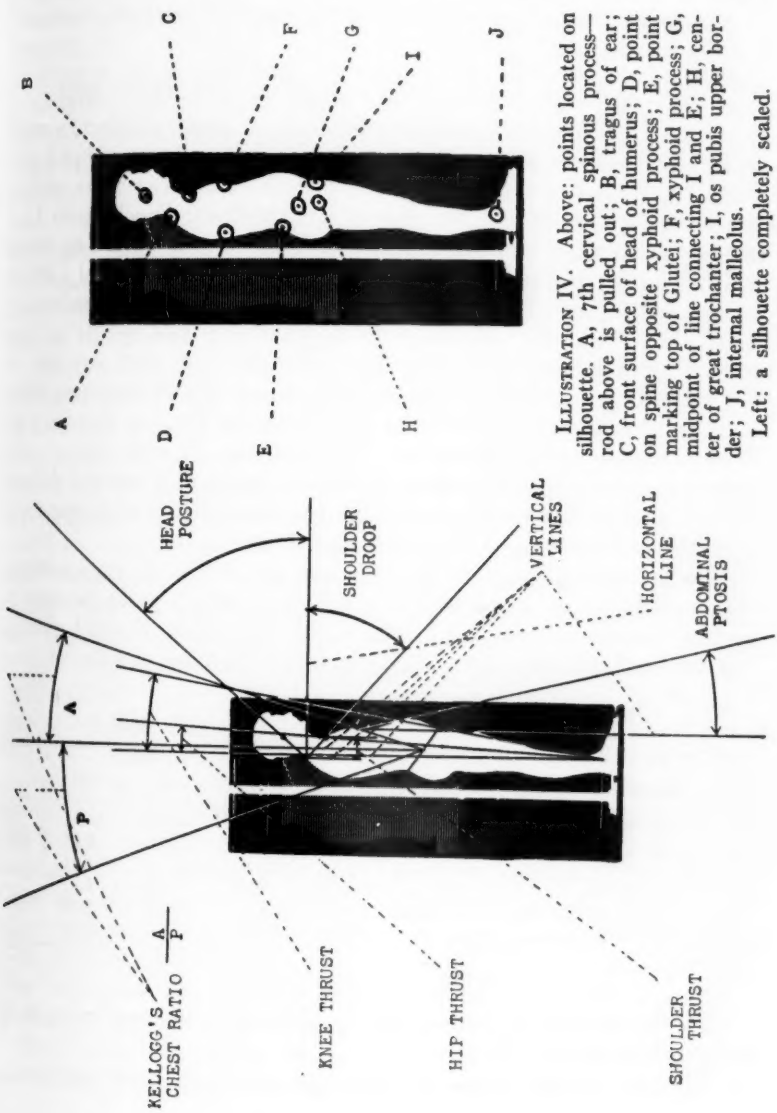

ILLUSTRATION IV. Above: points located on silhouette. A, 7th cervical spinous process—rod above is pulled out; B, tragus of ear; C, front surface of head of humerus; D, point on spine opposite xyphoid process; E, point marking top of Glutei; F, xyphoid process; G, midpoint of line connecting I and E; H, center of great trochanter; I, os pubis upper border; J, internal malleolus.

Left: a silhouette completely scaled.

with the Sargent Vertical Jump. No doubt the way men stand in this standardized procedure reflects their muscular tone and strength fitness. There is a relationship of this test to body type with the massive skeletoned men giving the highest ratings and the ectomorphs the lowest. A deep pelvis type with heavy Glutei muscles will stand with the weight a little more forward to bring the center of it over the center of the base. The correlations reflect the association with mesomorphic types and the strength tests.

Clarke and Shea [16] have published an improved method of measuring the lateral spinal curves.

INCIDENCE OF POOR POSTURE IN BOYS AND YOUNG MEN

Siemsen and Dolan [83] report the incidence of postural defects among senior high school boys: faulty anteroposterior posture (56.6 per cent); scoliosis (49.0 per cent); unequal shoulders (41.5 per cent); flat feet (37.7 per cent); bow legs (13.2 per cent); knock knees (7.5 per cent). Excellent posture in young men seems to be rare. Lee, Geer, and Brown, at Harvard,[58, 59] and Cook, at Yale,[18] found only about 20 per cent of entering college freshmen with good body mechanics. Later, Dr. Anderson, of Yale,[3] in summarizing the results of the postural examination work with the freshmen states that 497 out of 861 were assigned to the corrective department. Under Professor Kiphuth and Instructor Wickens the 1941 entering class of 849 men at Yale gave the following results: ideal posture (3 per cent); mild defects (32 per cent); moderate defects (44 per cent), marked defects (21 per cent). In summary, 35 per cent were excused and 65 per cent, 553 men, were placed in corrective classes.

Phelps and Kiphuth [71] in summarizing the results of 5256 postural examinations on boys and men give tables to show a great increase of postural defects associated with the adolescent period of rapid growth. The types of difficulties found in 3503 college men are as follows:

TABLE II

PERCENTAGE OF POSTURAL DEFECTS IN 3503 YALE MEN

Types of Defects	Perfect	Rating by Degrees 1	2	3
Over-all posture		2.31	84.64	13.04
Neck posture	33.51	47.44	17.38	1.65
Shoulder posture	74.14	23.00	2.79	.03
Kyphosis	60.67	27.86	10.26	1.17
Lordosis	38.21	35.15	21.35	5.28
Scoliosis	55.00	30.11	12.61	2.25

CAUSES OF POOR POSTURE

The causes of poor posture may be multiple as has been adequately suggested by Carey: [14]

The dynamic equilibrium of the muscles and bones of the back leading

to permanent structural changes in the bodies of the vertebrae, intervertebral discs, ribs, shoulder and pelvic girdles and lower extremities, may be upset by different pathological conditions in the following systems of the body: (1) digestive, (2) blood and lymph vascular, (3) respiratory, (4) excretory, (5) nervous, (6) osseous, (7) joint, (8) muscular systems.

Carey describes in detail the results of nutritional starvation experiments in which the muscles diminish in size and lose tone and weight progressively in the cervical muscles, the extremity muscles, the pectoralis major, the heart, the rectus abdominis, and finally the smooth musculature.

Most of the authorities in corrective work believe that poor posture is caused by unbalanced pull of muscles, inadequate muscular tone and low energy level. Overly strong and short Pectorals will cause round shoulders; weak supinator muscles of the feet will result in pronated feet; unusually strong and short Psoas-Iliacus muscles will cause lordosis; weak rib elevators will cause poor chest posture; a weak diaphragm will result in inadequate breathing. The problem here seems to be more in the area of *tone* rather than optimum muscular strengths because the experiments to connect dynamometrical strength to posture have so far resulted in failure.[78, 92, 66]

Apart from optimum strength and tone, the body is covered with muscles which act like stretched rubber bands. Illustration V shows a model which reproduces the curves of the back by balanced muscle pull. Carey[14] has constructed a similar model which reproduces the scoliosis curves, saying that "Scoliosis is a spinal sign of muscle-tone imbalance and is not a specific disease entity." The writer obtained proof as to the physical elasticity of muscles influencing the curves in experiments conducted in the Yale Medical School in 1932. Undissected cadavers were used, the pelves fixed, and the spines flexed with measured force pulling through a standard leverage distance. When the bodies were flexed forward on the thigh, lordosis persisted in a measurable amount but when the lower back muscles were cut, the lordosis disappeared. Careful measurements made on the bodies of the vertebrae indicated that the amount of the curvature could not possibly be accounted for by the shape of the bones but primarily by the pull of muscles acting either voluntarily, with involuntary tonicity, or physically because of the inherent elasticity of the sarcolemma. The curvatures are fairly independent because the lordosis and kyphosis measurements do not correlate above .200, the curvatures being due to the balance of muscular and gravity forces in each particular part of the spine. Schmidt and Miles[77] have published good material and diagrams to support this position, emphasizing the great flexibility of the spine due to the intervertebral cartilages.

Each aspect of posture needs to be analyzed neurologically and mechanically-kinesiologically. The long-time forces, not necessarily of

great magnitude, will be found to be the principal causes, ultimately influencing even the shape of the bones within reasonable limits.

The inherited shape of bones must not be neglected. Short clavicles may be the cause of round shoulders; frail vertebrae, the cause of exaggerated spinal curves; femoral torsion the cause of lordosis and foot stance; pelvic type predetermining spinal lumbar curvature; and uneven leg lengths causing lateral deviations of symmetry.

The postural measurements do not correlate highly with each other, most of the relations of distinctly different items being below .300. This is support for the belief that each aspect of posture is due to specific mechanical forces and neural learnings, so they must be dealt with specifically.

BASIC PRINCIPLES OF CORRECTION

A few basic principles of correction may be summarized:

1. The stretching of short muscles by (*a*) free exercises, (*b*) passive manipulation, (*c*) hanging or other uses of gravity.

2. The holding of a joint in a plaster cast for several weeks, the muscles taking the relative lengths in which they are held for long periods of time.

3. Standing, sitting, walking, and exercising with the body in good mechanical positions for physiological and skill efficiency.

4. Strengthening the active muscles (*a*) by general dosage, (*b*) by short static contractions.

Carnett and Bates [15] state "improvement in body mechanics is directly dependent upon and proportionate to the amount of time in which the individual holds his body in the corrected position." Postural exercises no doubt have a conditioning value. Any person, knowing a good set of postural exercises may do them at home, in the office, and throughout life. No special equipment, or "team," or gymnasium, or costume, or other organizational restrictions are necessary. In general, these exercises aim to strengthen, tone, and develop a kinesthetic sense of good posture for the muscles controlling the head, chest, spinal curves, pelvis, and feet. McCurdy [63, 64] has given some good suggestions for exercises and there are a number of additional sources.[6, 22, 40, 49, 60, 70, 71, 72, 84]

CONCLUSIONS

1. Postural fitness is a basic type of fitness, worthy of educational effort.

2. Development of good posture requires consideration of the mental, physiological, and morphological aspects.

3. The evidence shows strong relationships of posture to health but these concepts must not be applied within too narrow limits, except for preventive purposes.

4. Postural norms will be constructed which will treat each item separately with schemes to separate the morphological aspects from

the physiological and mental aspects, requiring normative groups with relationship to body build categories for those items which are markedly affected by heredity. Certain items are strongly affected and others are not.

5. Posture can be judged satisfactorily by experts who are trained in the related principles of body mechanics.

6. "Composite" or "average" posture scores are usually misleading and are inadequate for validity evidence due to the poor intercorrelation between items and the inconsistency and incommeasurability of the scales.

7. The causes of poor posture are multiple but many of them are "educable," not being dominated by hereditary morphology.

8. Certain basic principles are known but further research is needed on the quality and quantity of corrections and learning induced.

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CHAPTER IV

Fitness of the Feet and Legs

By THOMAS K. CURETON *

VARIOUS studies have shown that nearly *three-fourths* of the population of young adults have symptoms of weak feet. Studies by Arrowsmith,[4] Brown,[8] Keith,[17] Lewi,[19] Morton,[25, 26] Pollock,[29] and the U.S. Public Health Reports [2] support this conclusion. A much more extensive review of the literature on this problem may be found in Ruth Calvin's study, *Kinesiology of the Human Foot*.[9] Morton [25, 26] states that foot disorder is the most common form of physical impairment among civilized peoples today with the sole exception of dental decay. The seriousness of the problem is reflected in the rejections from the army, police departments, fire departments, and postal positions.

STUDIES ON THE CONDITION AND EFFICIENCY OF THE FEET

A previous study of 135 college men [11] in 1935 demonstrated extremely low validity of the *footprint angle,* although Clarke [10] had shown that this angle could be reliably and objectively measured. The criteria used were practical things that people do on their feet, such as, running, jumping, lifting, weight bearing, balancing, and also strength and flexibility tests involving vigorous use of the feet. These validity correlations ranged from $-.174 \pm .092$ to $.297 \pm .066$. Many athletes with arch angles below 21 degrees (below -2σ in a distribution of 600 cases) were shown to be efficient in sports which demanded the hardest possible use of the feet. The foot sizes ranged from 3.3 to 4.5 inches in width and from 9.2 to 11.0 inches in length. Schwartz, Britten, and Thompson,[36] in experiments on high school boys were unable to show any improvement in the angle after specific conditioning for this purpose. These studies show that other types of tests must be used to separate good feet from poor feet, although it is quite possible that ordinary statistical methods are inadequate to show the true value of footprints with certain cases. Flat prints may or may not mean poor condition.

CRITERIA FOR FOOT EFFICIENCY

If feet are very painful, possess any swollen or disarranged structures, a person is not likely to want to jump up and down on them vigorously on a hard surface. Sensitiveness will be shown to pressure

* The writer is indebted to W. T. Holmes for collaboration on this project in carrying out the study "Tests of Foot Condition" (16).

put upon them naturally by the body weight or artificially from above. It is also likely that efficiency in vertical jumping will be impaired. Inspection of the feet will show tell-tale signs in weak feet cases, such as: pronation, angulation of the heel cord, bulging scaphoid and inner malleolus bones, deformed toes, inward deflection of the big toe, bunions, calluses under the ball of the foot, or deterioration of skin under and beneath the toes. These signs point to poor foot hygiene and inadequate exercising. Inability to jump vertically as well as might be expected for one's physical type reflects some of these conditions. These positive signs are most objective and stress the *functional* characteristics related to efficiency in the use of the feet.

Medical authorities on the feet depend upon the criteria above for preliminary diagnosis of foot disability. Nine outstanding foot specialists were canvassed regarding their opinions about the validity of some of the measurable items to indicate foot efficiency. They rated in order of importance (1) scaphoid deviation, (2) how one stands on his feet, (3) vertical jump, (4) toe flexion strength, (5) height of scaphoid bone, (6) foot extension strength, (7) heel cord deflection, (8) great toe angle, (9) width of foot, (10) height of internal malleoli, (11) arch angle, and (12) width of malleoli. In addition to these objective criteria which are measurable, physicians hold in mind many other signs of disability, relating bad feet to the general condition of the body, weight status, medical history, and specific causes both inherent and environmental. It is interesting that 27 out of 40 orthopedic surgeons thought that more information was needed to determine the condition of the feet than the items listed above, whereas 13 thought that the items were inclusive enough,[16] (pp. 99:112; 127–134).

The *vertical jump* alone is not a bad criterion if normed within body build groupings. The power of the jump is applied through the foot as a lever. It involves an exaggeration of the action involved in the walking step as described by Schmidt and Sputh (Illustration I): [33]

> In stepping, the elastic arch of the instep, firmly constructed, sinks under the body weight, the front of the foot and toes spread like a fan and the toes brace themselves like elastic springs against the ground.

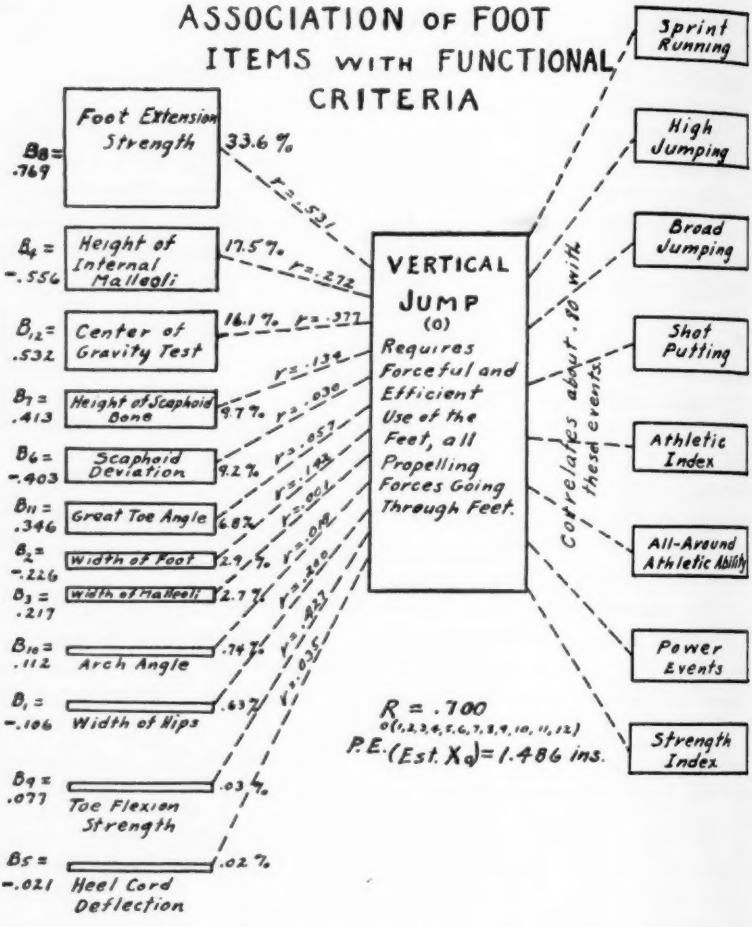
The vertical jump is a good test of the power and condition of the muscles in the foot and leg within limitations of body build classifications, meaning that it is a more valid reflection of condition if people of the same physical type are compared. Meredith [24] emphasizes the fundamental importance of the condition of the muscles of the foot and leg in order to prevent weak feet:

> Usually, however, flat foot means only weak feet, the weakness being of an entirely preventable sort. Because the foot is weak, it is both flat and inefficient. The weakness is a general weakness of all the muscles and ligaments of the foot and of the muscles of the leg that govern foot motion.

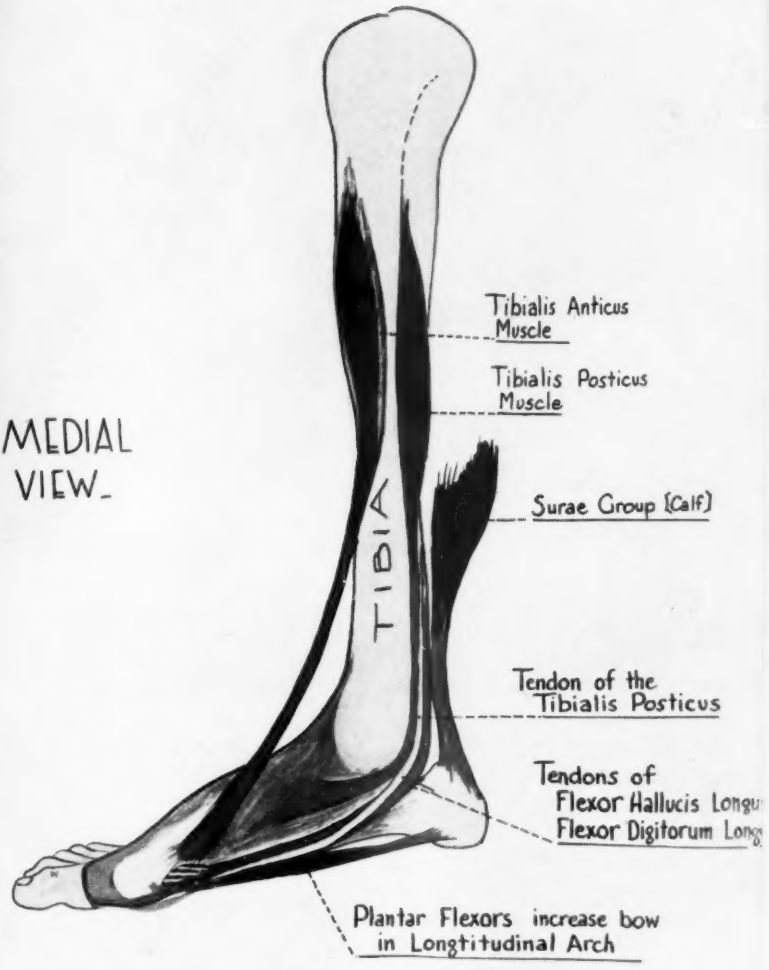
The tendency of the Tibialis posticus, Tibialis anticus, and Peroneous longus to invert or supinate the foot, thus counteracting the tendency toward pronation, supports the idea that the condition of these muscles and others is fundamental (Illustration I). It may be argued that tests of foot condition should test the feet under conditions which

CHART A

ASSOCIATION OF FOOT ITEMS WITH FUNCTIONAL CRITERIA



will bring into play the muscles of the foot and leg as used in jumping, rather than be based primarily upon superficial criteria, such as, footprints, minor ailments, and general appearances. The vertical jump has been found to be about the best single predictor of ability in a wide range of power events.[22] Chart A shows the relations which the vertical jump has to body mechanics and to athletic ability. It represents the general plan of testing the objective foot measurements against the ver-



SUPPORT FOR THE LONGITUDINAL ARCH OF THE FOOT

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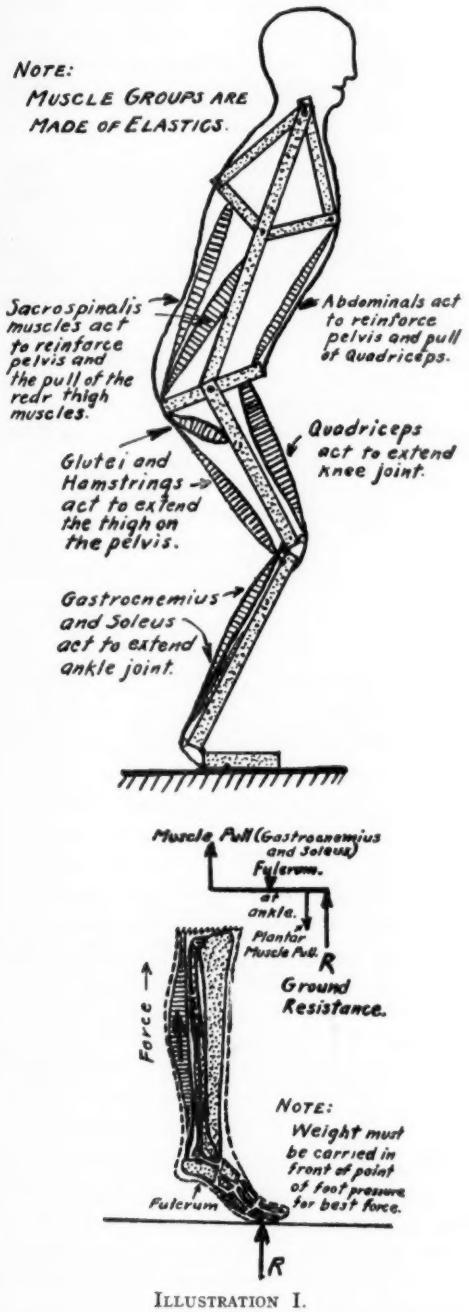

NOTE:
MUSCLE GROUPS ARE
MADE OF ELASTICS.
Sacrospinalis muscles act to reinforce pelvis and the pull of the redr thigh muscles.
Abdominals act to reinforce pelvis and pull of Quadriceps.
Quadriceps act to extend knee joint.
Glutei and Hamstrings act to extend the thigh on the pelvis.
Gastrocnemius and Soleus act to extend ankle joint.
Muscle Pull (Gastrocnemius and Soleus)
Fulcrum. at ankle.
Plantar Muscle Pull.
R
Ground Resistance.
Force
NOTE:
Weight must be carried in front of point of foot pressure for best force.
Fulcrum
R

ILLUSTRATION I.

tical jump for their validity of association with dynamic activities using the feet.

It was decided to correlate certain of the objective measurements of the foot with the vertical jump, using 100 feet cases of high school boys. This work was carried out by Holmes.[16]

TABLE I

CORRELATIONS OF FOOT MEASUREMENTS WITH VERTICAL JUMP CRITERION

Item	Coefficient of Objectivity	Coefficient of Reliability	Correlation Right and Left Feet	Correlation with Vertical Jump
Foot extension strength .	.960	.924		.531
Toe flexion strength	.963	.863	.851	.427
Center of gravity	.950	.948		.377
Height of medial malleoli	.942	.836	.936	.272
Width of hips	.978	.935		.200
Width of foot	.837	.812	.877	.142
Height of scaphoid bone .	.800	.853	.838	.144
Great toe angle	.967	.738	.350	.057
Heel cord deflection	.798	.773	.705	.035
Scaphoid deviation	.862	.854	.767	.030
Arch angle	.965	.902	.708	.015
Width of malleoli	.948	.923	.933	.001
Vertical jump	.963	.974		Criterion

TABLE II

INTERCORRELATIONS OF ALL OF THE FOOT MEASUREMENTS

	0	1	2	3	4	5	6	7	8	9	10	11	12
1.	.200	.935											
2.	.142	.466	.812										
3.	.001	.493	.623	.948									
4.	.272	.414	.313	.393	.836								
5.	.035	.250	.033	.111	.156	.773							
6.	.030	.109	.043	.260	.111	.368	.859						
7.	.134	.167	.091	.149	.623	.269	.244	.853					
8.	.531	.358	.347	.194	.490	.329	.301	.218	.924				
9.	.427	.337	.371	.404	.209	.187	.075	.075	.514	.863			
10.	.018	.004	.048	.196	.428	.054	.167	.604	.016	.012	.902		
11.	.057	.113	.118	.104	.027	.045	.000	.242	.004	.122	.233	.738	
12.	.377	.308	.184	.263	.390	.085	.110	.211	.204	.314	.023	.390	.948

Key:

0 = Vertical Jump
1 = Hip Width
2 = Foot Width
3 = Malleoli Width
4 = Malleoli Height
5 = Heel Cord Deflection
6 = Scaphoid Deviation
7 = Scaphoid Height
8 = Foot Extension Strength
9 = Toe Flexion Strength
10 = Arch Angle
11 = Big Toe Angle
12 = Center of Gravity

Regression Equations to Predict Vertical Jump *

I. *Static Alignment Test No. 1* (Combining scaphoid height, foot width, and malleoli height to predict vertical jump)

A. Vertical Jump (in standard score units) = —.048 (Scaphoid Height + .058 (Foot Width) + .284 (Malleoli Height) [standard score form equation]

* The statistical work supporting these equations may be found in the master's thesis by William T. Holmes.[16]

B. Vertical Jump (in inches) = —.525 (Scaphoid Height) + .892 (Foot Width) + 4.376 (Malleoli Height) + 1.046 [score form equation]

$R = .281$ $P.E._{(Est.\ X_0)} = 2.007$ inches

II. *Static Alignment Test No. II* (Combining scaphoid deviation, big toe angle, scaphoid height, foot width, and malleoli height to predict vertical jump)

Equation omitted because adding scaphoid deviation and big toe angle contributed very little in addition:

$R = .290$ $P.E._{(Est.\ X_0)} = 2.001$ inches

III. *Static Alignment Test No. III* (Combining scaphoid deviation, big toe angle, scaphoid height, foot width malleoli height, and center of gravity test to predict vertical jump)

$R = .410$ $P.E._{(Est.\ X_0)} = 1.907$ inches

IV. *Static and Functional Test No. IV* (Combining malleoli height, toe flexion, ankle extension, center of gravity to predict vertical jump)

A. Vertical Jump (standard score units) = —.084 (Malleoli Height [ins.])+.126 (Toe Flexion Strength [lbs.])+.451 (Ankle Extension Strength [lbs.]) + .278 (Center of Gravity [cms.]) [standard score form equation]

B. Vertical Jump (inches) = —1.296 (Malleoli Height) + .029 (Toe Flexion Strength) + .019 (Ankle Extension Strength) + .573 (Center of Gravity) + 11.89 [score form equation]

$R = .613$ $P.E._{(Est.\ X_0)} = 1.65$ inches

In the above equations and statistical results it may be seen that the foot structure correlates positively but low with vertical jumping. Addition of the center of gravity test increases the multiple R from .281 to .410, increasing the efficiency of prediction about four times. Further addition of the toe flexion and ankle extension strengths raises the multiple R to .613, indicating the great importance of the foot and leg strengths in vertical jumping. These findings corroborate the theoretical principles related to muscular conditions stated at the opening of this paper. Combining all thirteen items gives a multiple R of .700, $P.E._{(Est.\ X_0)}$ = 1.486 inches. These items rank in the following order according to the square of the Beta weights shown in parentheses: vertical jump (the criterion), foot extension strength (.590), height of internal malleoli (.308), center of gravity test (.282), height of scaphoid bone (.171), scaphoid deviation (.162), great toe angle (.120), width of foot (.051, width of malleoli (.047), arch angle (.013, width of hips (.011), toe flexion strength (.006), heel cord deflection (.004).

THE MEASUREMENTS OF IMPORTANCE

It is important to know how to measure the feet. The significant measurements will be briefly described; these are listed in order of their Rank-Product Index (product of the experimental and opinion ratings), indicating over-all relative value of each item for indicating efficiency of the feet:

1. *Vertical Jump.*—The technique of measuring the vertical jump

is described in several sources.[22, 28, 31, 32] A simplified scheme is shown in Illustration II-A, using the Visiometer to spot the height of the jump to the nearest inch by means of the white button marker placed around the ankle as shown. The anklet is adjusted to the zero line on the cardboard scale. The chalk-mark method is common.

2. *Scaphoid Deviation.*—Medical authorities rate the scaphoid deviation first as an indicator of foot condition. Two methods are shown for measuring it in Illustrations II-B and II-C. The basic principle is to measure the inward bulging of the scaphoid bone beyond the line connecting the inner side of the heel and base of the big toe with the blocks held tight against the side of the foot. The device is called the Pronation Ruler.

3. *Center of Gravity Test.*—This is adequately described in the literature.[13]

4. *Foot Extension Strength.*—Illustration II-D shows the foot extension strength test. The straps are placed on a line even with the balls of the feet, taken up tight, and the subject is watched carefully to see that he doesn't lean forward. The hand is held in front of the forehead as a check against this.

5. *Height of Scaphoid Bone.*—Illustration II-E shows the method of taking the scaphoid height. The most prominent point on the scaphoid is marked with flesh pencil and then measured.

6. *Height of Internal Malleoli.*—Illustration II-F shows the method of measuring the height of the internal malleoli. The measurement is taken to the most prominent point on the lower edge of the internal malleolus.

7. *Toe Flexion Strength.*—Illustration II-G shows the methods of measuring the toe flexion strength. The press block is placed perpendicular to the central axis of the foot so that the little toe can just exert its pressure on the block.

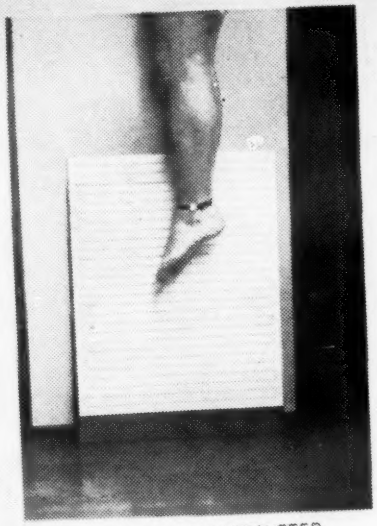
8. *Great Toe Angle and Lever Ratio.*—Illustration II-H indicates the scheme for measuring the great toe angle and also the lever ratio which was not used in this study.

9. *Width of Malleoli and Foot.*—Illustration II-I shows the method of measuring the width of the foot. The same calipers are used to determine the width of the malleoli.

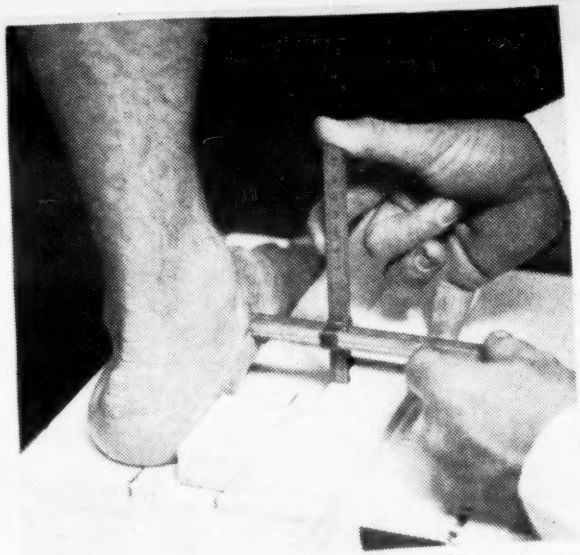
10. *Arch Angle.*—This measurement is adequately covered in the literature.[10, 11]

NORMS FOR YOUNG MEN

Chart B shows the individual differences which exist on thirteen different measurements. Items 10, 11, 12, and 13 show the results obtained from the regression equations. Senior high school boys and college freshmen may be matched satisfactorily on this scale. Insufficient work has been done to norm the jumping by body type groupings. This should be the goal in a future study.



A. VERTICAL JUMP VISIOMETER

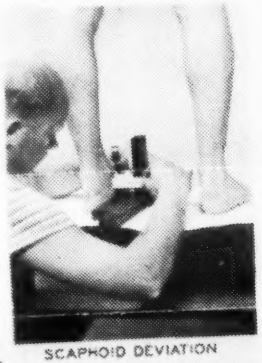


B. SCAPHOID DEVIATION

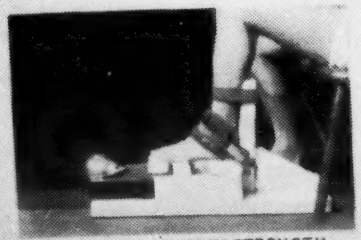
ANKLE EXTENSION STRENGTH D.

E. SCAPHOID HEIGHT

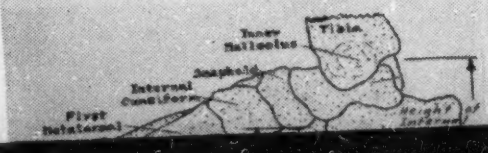
I. FOOT WIDTH

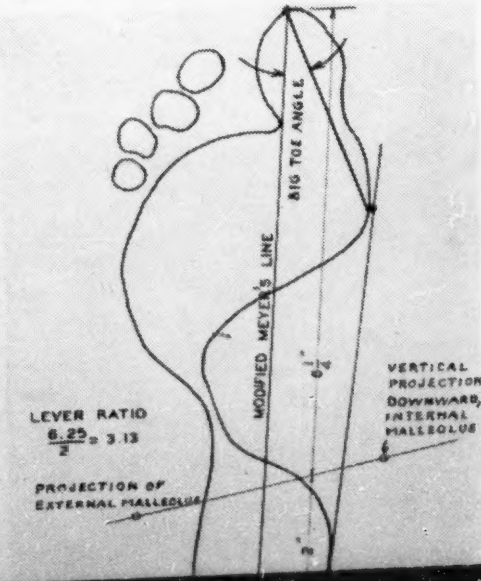


C. SCAPHOID DEVIATION



G. TOE FLEXION STRENGTH





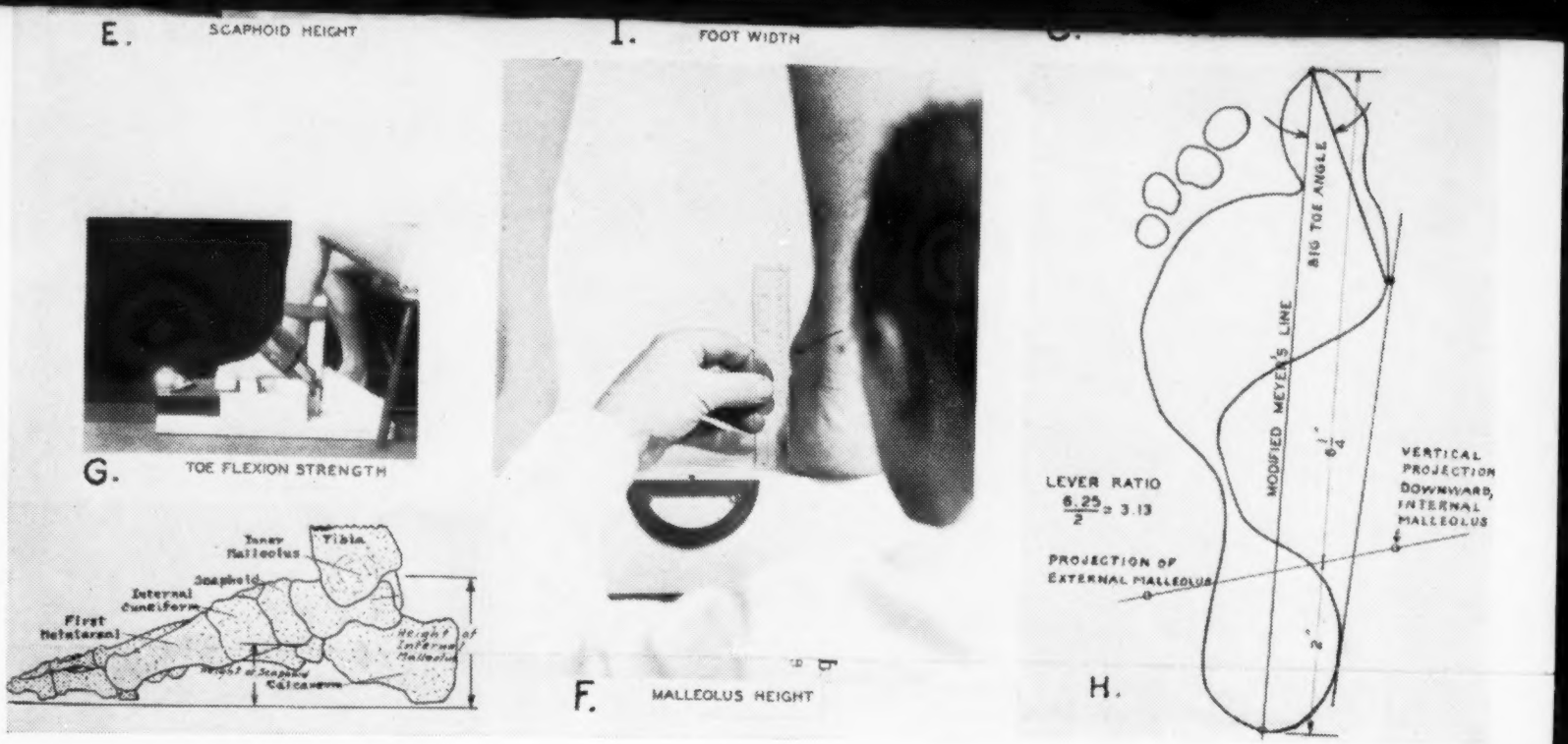
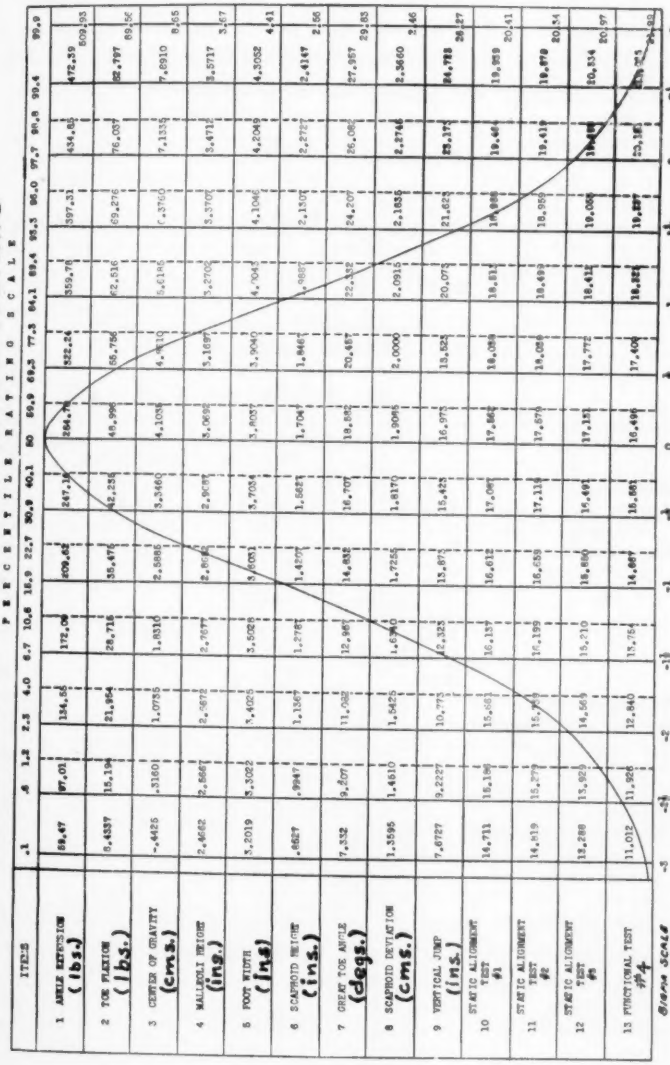


Illustration II.

UNIV. OF MICH.

COMPOSITE TEST OF FOOT AND LEG EFFICIENCY

Considering the two sets of evidence, (1) the opinions of the orthopedic surgeons, and (2) the objective validity correlations, it is obvious that both have value. Five items have been selected from both sets of evidence to obtain the items which can be most consistently supported. These have been weighted approximately in proportion to the reciprocals of the rank-product values. The *multipliers* weight the items in terms of their contribution to mechanical efficiency. The jump-



ing criterion is not sufficient for a criterion. It is possibly most important but the doctors recognize the relation between abnormal anatomical arrangements, poor foot balance, and physiological function. Pronated and flat feet result in pain and interference with the function of the ankles, knees, hips, and frequently cause backache. Mal-alignment

Step 1 QUESTIONNAIRE ABOUT THE FEET

Date .....
Name ..... Age ..... Height .....
Address ..... Weight ..... Body Type .....

	Yes	No
1. Have you ever been to a doctor about pains in your feet?	.....	.....
If so, why?		
Details		
2. Have you ever had any pains in the arches of your feet?	.....	.....
Where		
Details		
3. Have you ever injured your feet?	.....	.....
If so, how recently?		
Details		
4. Do you have any complaint to make about your feet?	.....	.....
If so, what?		
If so, what?		
Classification: Feet seem all right, excused from further tests	.....	.....
Feet seem questionable, suspend judgment	.....	.....
Should be referred to orthopedist at once	.....	.....

Step 2 INSPECTION AND MANIPULATION OF FEET

(Encircle the number below which corresponds to your judgment)

	Deviates	Satisfactory	Excellent
1. Bound up and down on the balls of your feet, as high as possible. Any pains in your feet?	1 2 3 (0 to 9 ins)	4 5 6 7 (10 to 20 ins.)	8 9 10 (20 ins. and up)
2. Put pressure on foot to note any sensitiveness:			
(a) Toes	1 2 3	4 5 6 7	8 9 10
(b) Transverse Arch	1 2 3	4 5 6 7	8 9 10
(3) Medial Long Arch	1 2 3	4 5 6 7	8 9 10
3. Voluntary circumduction, note range of flexibility	1 2 3	4 5 6 7	8 9 10
4. Evidence of pronation, note heel cord and scaphoid bone	1 2 3	4 5 6 7	8 9 10
5. Control of toes in flexion and extension	1 2 3	4 5 6 7	8 9 10
6. Hygienic Appearance: Note corns, calluses, skin between toes, skin over whole foot	1 2 3	4 5 6 7	8 9 10
7. Standing: Note stance and angulation of big toe	1 2 3	4 5 6 7	8 9 10

Classification: Sum of Scores.....

Excused .....
Questionable .....
Refer to orthopedist ..... Examiner .....

FORM FT.

of the joint surfaces causes increased strain upon the supporting muscles and ligaments, interference with blood and lymph supply, and improper use of articular cartilages. Such abnormal relations frequently give rise to chronic joint disease. The orthopedists are interested in these latter types of criteria, and put confidence in careful inspection of the feet. Therefore, an efficiency test may be constructed but it must be supplemented by experienced inspection and diagnosis.

SCREEN TESTS FOR CONDITION OF THE FEET

Steps to be taken in making an appraisal or "screen test" of the feet are suggested as follows:

1. Question subject to determine history of feet.
2. Inspect and manipulate the feet to determine signs of strain, weakness, or poor flexibility.
3. Give the measurements and score the *Functional Foot and Leg Test.*

Step 3 FUNCTIONAL EFFICIENCY TEST FOR FEET AND LEGS

Name ..... Age ..... Body Type .....
Address ..... Weight ..... Height .....

Items	Units	Raw Scores	T-Scores	Multiplier	Product
1. Vertical jump (chalk mark method)	Ins.			3	
2. Center of gravity (using Cureton-Wickens)	Cms.			2	
3. Toe flexion strength (using portable scales)	Lbs.	(Average)		2	
4. Scaphoid deviation (using pronation ruler)	Cms.	(Average)		1	
5. Height of scaphoid	Cms.	(Average)		1	

Total Score.....

Examiner.....

Note on Test: The multipliers are approximately proportional to the rank-product reciprocals, which have the values for vertical jump (.33), center of gravity test (.166), toe flexion strength (.125), scaphoid deviation (.100), and height of scaphoid (.029). The toe flexion strength has been given a multiplier in view of the objective studies rating this item second. The T-Scores may be estimated closely enough from Chart B. The procedure includes (1) making the measurements, (2) posting the raw scores on form FT, (3) looking up the T-Scores on Chart B and posting these on form FT, (4) multiplying the T-scores by the multipliers and putting the results in the product column, (5) summing the product column to obtain the total score.

The total score may be used as an objective classifying device within age band and body type groups. Norms are not yet available for the test scores. When sufficient data are available this total score may be further validated by correlation with a large number of variables.

CONCLUSIONS

1. Various studies show that nearly three-fourths of the population of young adults have symptoms of weak feet due to poorly conditioned foot and leg muscles and hygienic abuses involving poorly fitting footgear.

2. Footprints should be taken of all cases but this device should be considered a supplementary device rather than a basic procedure in testing functional foot efficiency. The Pedograph as a single method is not a reliable guide for classifying foot cases. Weak foot cases may or may not give flat prints; likewise, powerful feet may or may not give flat prints.

3. Criteria for condition of the feet and legs may include athletic events executed on the feet, particularly the vertical jump, but in addition the criteria used by orthopedic surgeons for judging malalignment of the anatomical structures and physiological disorder should be included in empirically constructed test batteries.

4. An empirically constructed test for the feet and legs is proposed for trial, giving equal weight to the orthopedist's judgments and the objective correlational evidence with functional criteria.

5. A routine is proposed for examining the feet.

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CHAPTER V

Flexibility as an Aspect of Physical Fitness

By Thomas Kirk Cureton

FLEXIBILITY AND FITNESS *

ARE you fit? Can you touch your palms to the floor in front of your toes while holding the knees straight? This is an age old concept of fitness in a popular sense. "Muscle-bound" individuals are reputed to be poor in running and swimming endurance. On the other hand an extremely flexible individual may have such loose and flimsy ligaments binding the joints that they are easily dislocated or strained. Finally old age is marked by stiffness in the joints and accompanying physical awkwardness.

Relationships like the above make one area of fitness for investigation and interpretation. Some of these relationships have marked implications for training and conditioning work in athletics, in first aid and therapeutic work, and in keeping the body fit throughout life.

INVESTIGATION OF FLEXIBILITY EXERCISES

Flexibility exercises have never been studied intensively since some of the necessary aspects are not measurable in the living human subject. Such research would probe such aspects as: (*a*) The specific anatomical relations in the joints, (*b*) The physical characteristics of the tissues, (*c*) The cause of the so-called "muscle-bound" condition, (*d*) The influence of reciprocal innervation and tonus in specific exercises, (*e*) The balance of the muscle tensions over any particular joint, (*f*) The influence of age, (*g*) The influence of injuries, (*h*) Relationships to skill, warm-up, and endurance, (*i*) Relationships to posture and corrective work.

Some basic principles which may be postulated until such investigations are concluded are as follows:

1. Flexibility exercises are not passive movements in the true sense because joint flexion movements are opposed by the resistance of opposing muscles, tendons, and ligaments, since these structures have elastic properties. Dynamic contraction of the active muscles is involved.

2. Flexibility exercises and tests measure the extent to which the active muscles may be shortened and the antagonistic muscles elongated. Marked

* *Flexibility* means the capacity to bend, or to be flexed or extended without breaking; to be pliant, not stiff, or brittle. Similar words are limber, lithe, and supple. The term has an inverse relationship to elasticity, since the stretched tissues have elastic resistance.

differences between individuals of the same age and approximate size may indicate differences between "long" and "short" muscle types, differences in physical type and innate patterns of the bones, muscles, and ligaments involved.

3. Flexibility exercises applied to young men of the college age range reflect a type of condition, called "suppleness," which is a measure of the full-range mobility of the joints, reflecting the structural capacity, the normality of the joints, the relative strength compared with the capacity of the body to relax the opposing muscles (reciprocal innervation), and the type and state of condition of the musculature.

4. Flexibility exercises may be given for conditioning in the sense that the full range contraction and extension of the muscles is excellent massage and exercise for the muscles, producing both a physical elongation and a strengthening of the musculature. Such exercises, if built up to sufficient dosage, may condition muscles, tendons, ligaments, and bones to greater tensile strength and elasticity, a factor which is basic to preventing injuries in many sports.

5. The flexibility exercises are more conducive to building endurance in movements like swimming, running, acrobatic dancing, and tumbling than short static or weight lifting types of exercises.

INTERNAL RESISTANCE IN THE TISSUES, THE CONDITION CALLED "MUSCLE-BOUND"

The bony skeleton is covered by musculature, joined to the bones by tendons, and held in place by ligaments. Every movement of the body involves stretching the muscles and ligaments which oppose the motion. The muscles and ligaments are analogous to stretched rubber bands and overcoming this resistance is one of the principal sources of wasteful work and physiological fatigue. The human machine would have much greater efficiency than 4–33 per cent, as a range for various physical activities, reported by various physiologists if it were not for the magnitude of this internal resistance. In endurance exercises, it would seem to be fundamental to try to reduce this internal resistance by improving the neuro-muscular control (including reciprocal innervation), by reducing the internal viscosity of the tissues, and eliminating all adhesions and needless fat around the joints and in the muscles.

In the relatively full range movements of Danish Gymnastics, swimming, diving, hurdling, high jumping, high kicking, vaulting, running, and tumbling, one may literally "wear oneself out stretching his own elastics." These relations have not been fully investigated but good trainers pay much attention to flexibility work in all of these activities. As muscles are contracted and then extended to the limit, the sarcoplasm of the muscle must change its shape within the confines of the muscle bulk with some restriction due to the fibrous tissue and fat. In slow exercises this is not of much consequence but in exercises of speed and endurance great energy is needed to overcome this internal resistance. Hill [16] states that the speed of sprint running is primarily limited

A GROUP OF FLEXIBILITY EXERCISES.

STRETCHING THE QUADRICEPS AND ANKLES.

STRETCHING THE PECTORALS.

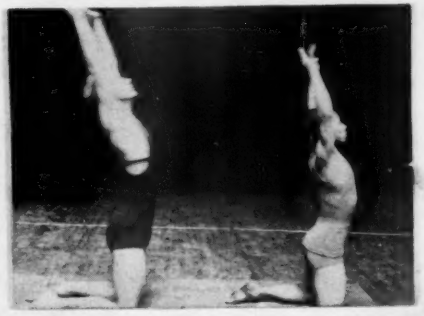
STRETCHING THE SHOULDERS HANGING EXERCISES.

STRETCHING THE GLUTEALS

STRETCHING THE ADDUCTORS.

STRETCHING THE CHEST AND ANKLES.

STRETCHING THE HAMSTRINGS AND LOWER BACK.



STRETCHING THE SHOULDERS AND CHEST, ALSO, THE ABDOMINALS.

by the internal viscosity and the strength of the structures. Since the viscosity resistance varies as the square of the speed of the movement, it becomes of great importance in speed exercises.

Capretta[5] reports the results of a study in which a questionnaire was sent to 45 physiologists. Out of 22 replies only 7 ventured opinions as to what the causes of "muscle-bound" condition were. As a summary to these replies, Capretta states:

"The outstanding opinion seems to be that the condition of *muscle-bound* is associated with hypertrophy, and is a condition of over-growth or excessive development of the muscles. It is seen commonly when training is associated with severe muscular strain. The excessive development results in a condition of fibrosis resulting in a preponderance of fibrous linen in muscle bundles due to the amount of stress and strain to which the muscle is subjected."

Fenn states the following opinion:

"*Muscle-bound* is a term applied to the general condition found in athletes accustomed to heavy muscular work involving the use of large masses of muscles without fine gradations and precise control. Here I suppose that the muscle fibers are over-developed in relation to the nerve fibers so that one nerve fiber possibly controls a number of muscle fibers. This is reasonable if hypertrophy of the muscle involves an increase in the number of the fibers. Tendon sense and muscle sense are poorly developed or else the proprioceptive impulses are received *en bloc* rather than in detail. The subject performs delicate muscular movements awkwardly and without any fine adjustment."

RELATIONSHIPS OF FLEXIBILITY TO ATHLETIC SKILL AND ENDURANCE

The previous discussion suggests very important relationships to athletic performances and endurance. It is well to examine some samples of the evidence and examples of application.

Swimming.—A swimmer with relatively flexible ankles has the possibilities of more effective force for propulsion on every down-beat of the foot because in hyperextension of the ankle the water is driven backward and downward at a more favorable angle. The flip-like weaving of the ankle up and down resembles roughly the fish-tail action as has been shown by underwater photography and analysis.[7] In the use of the arms and shoulders, and chest in respiration, suppleness is a great asset because the movements may be made more easily without disturbing the all-important aspect of body balance, necessary for minimum resistance. Coaches have been known to steam out the muscles of the shoulder and back on backstroke swimmers. Likewise, flexibility conditioning exercises for swimmers have been made famous by Bob Kiphuth, Yale swimming coach, the trainers of the Japanese Olympic Champions, and by the followers of Danish gymnastics. Many of these exercises have been adapted to the conditioning of swimmers.

There is no doubt that better speed and endurance swimming performances parallel greater flexibility in the major joints: trunk extension, trunk flexion, ankles, and shoulders. In 1932 this hypothesis was tested by comparing some of the Japanese and American Olympic swimmers, at Los Angeles, with measurements taken on less efficient groups of the same age range. The four Japanese who broke the world's 880-yard relay record by 38 seconds averaged 31.3 per cent better on *trunk flexion* than the American team members. Twenty-one Olympic swimmers were shown to be superior as an average to 100 college competitive swimmers by 11.4 per cent in the ankles and 7.7 per cent in *trunk flexion.*

In 1934 a most remarkable difference was shown between the measurements taken on the Yale University swimming team and those of the Springfield College general student body:

TABLE I

COMPARISON OF YALE AND SPRINGFIELD COLLEGE MEN IN FLEXIBILITY

Test	Yale Varsity Swimmers Averages	Springfield Students Averages *
Trunk Flexion, Forward	6.1″	12.08″
Trunk Extension, Backward	34.7″	11.45″
Ankle Flexibility	65.1°	56.41°
Shoulder Flexibility	19.7″	12.90″

* These freshmen, involving the entire class of 150 men, were taken as a group against which various comparisons would be made.

The results above correspond to the following percentile differences in superiority for the Yale swimmers: 45, 80, 30, and 47 percentile units, respectively.

By 1938 sufficient data had been accumulated to compare the significance of group differences by the bi-serial correlational technique.[12]

Trunk Flexion Test

Springfield Freshmen vs. Dartmouth Varsity Swimmers..... $r_{bis.}$=.43
" " vs. Yale Varsity Swimmers..... $r_{bis.}$=.64
" " vs. Olympic Candidates (1932)..... $r_{bis.}$=.29
" " vs. Springfield Varsity Swimmers..... $r_{bis.}$=.33

Trunk Extension Test

Springfield Freshmen vs. Yale Varsity Swimmers (1936)..... $r_{bis.}$=.88
" " vs. Yale Varsity Swimmers (1932)..... $r_{bis.}$=.77
" " vs. Olympic Candidates (1932)..... $r_{bis.}$=.87

Shoulder Flexibility Test

Springfield Freshmen vs. Dartmouth Varsity Swimmers..... $r_{bis.}$=.64
" " vs. Yale Varsity (1936)..... $r_{bis.}$=.58
" " vs. Springfield Varsity Swimmers..... $r_{bis.}$=.23
" " vs. Olympic Swimming Candidates..... $r_{bis.}$=.42

Ankle Flexibility Test

Springfield Freshmen vs. Dartmouth Varsity Swimmers.....$r_{bis.}$=.38
" " vs. Yale Varsity Swimmers.....$r_{bis.}$=.35
" " vs. Springfield Varsity Swimmers.....$r_{bis.}$=.16

The measurements just given indicate that significant differences in flexibility parallel the group differences in swimming ability. The causes of these differences are not fully determined. Some of the difference may be due to swimming selecting out a greater proportion of tall, loose-jointed men (ectomorphs and meso-ectomorphs) who have greater flexibility due to their type of body build. Another possible cause is that swimmers actually have a type of musculature that is present by selection or by conditioning which is capable of greater extension or of relaxation of the antagonistic muscles.

RELATIONSHIP TO OTHER TYPES OF PHYSICAL PERFORMANCES

Correlation of the four flexibility tests used in the above studies with a wide variety of physical performances other than swimming have failed to show significant differences of great importance within the Springfield Data. The correlation of the *Trunk Flexion Test* with the Burpee Test † is .358 + .054, with the Sargent Vertical Jump, is .331 + .056. Most of the other correlations are insignificant. There is a technical difficulty within this work that tends to destroy these correlations, however. The tests are made on a relatively homogeneous group of men with the endomorphs and extreme ectomorphs lacking. Since the mean T-Scores increase steadily from endomorphic types, to meso-endomorphic, mesomorphic, meso-ectomorphic and ectomorphic types, this variable is so dominant that it influences all statistical work on these tests. Further research should hold out the body build factor, or equalize it experimentally. When this is done, the conditional differences will be more clearly seen. This is a much needed area for further research.

RELATIONSHIPS TO POSTURE AND CORRECTIVE WORK

It is common practice to give considerable flexibility work in body building and corrective classes. The assumption underlying this is that certain of the muscle groups become unduly shortened by being exercised in short static positions and with the opposing muscle groups poorly conditioned, the result is an imbalance of the muscular tensions for best posture. One method is to shorten up the weak antagonists, and this is usually done. The other approach is to stretch the shortened groups. The result should be better balance of the muscular tensions

† Done as fast as possible for 10 seconds, each movement counting one point: (1) From full standing position to full squat with hands in front of toes, (2) Full extension of the legs backward to forward rest position, (3) Return to (1), (4) Return to starting position.

with better posture of the particular segment as a result. An example might be forward shoulders, where the Pectorals have become unduly shortened and the Rhomboids too relaxed. The corrective work would concentrate on lengthening the Pectorals and shortening the Rhomboids. In lordosis, as another example, the thigh flexor muscles (Psoas-Illiacus) might be short from long sitting or exercising in the shortened position so that in standing they pull forward on the lumbar vertebrae causing some unusual degree of lordosis. A person with short, strong and inextensible Trapezius muscles will more than likely have high square shoulders. Lengthening the Trapezius muscles would give a more normal posture. A strong but supple body is sought rather than an unevenly balanced body strong in some places and weak in others. No doubt the ample dosage of flexibility exercises given in most of the "body building" classes offered in Body Mechanics and Corrective Departments leads to considerable normalizing of physique.

Correlation of flexibility tests with specific measurements of posture does not produce correlation coefficients of great significance. This is due to the body build factor being so dominant that systematic relationships between variables of flexibility and posture are lost in the usual unordered arrangement of body builds in such studies. Future research will attempt to hold out or equalize the body build factor and then sensible relationships may be shown between flexibility and aspects of posture.

RELATIONSHIPS TO PHYSIOLOGICAL AGE AND INJURIES

The tissues of babies are very flexible because of the cartilagenous nature of the bones, the extensibility of the structures generally, and because the great tonic and gross elastic forces of the heavier muscles have not developed. Hence, it is a popular idea that children are not very susceptible to injuries due to falls from their feet or from higher places. On the other hand, it is a common observation that older people are more easily injured, presumably because their physical tissues have lost suppleness. From youth to old age there is a gradual loss of flexibility in the joints and in the tissues, this even showing in the arteries causing higher blood pressure. Flexibility tests, normed over five or ten year age spans, would indicate a type of *physiological age* of considerable interest. Good flexibility for one's age and body build would indicate one type of youthfulness. Measurements of vital capacity, blood pressure, and joint actions are all measures of flexibility, when interpreted in this sense. The aging of the body shows up in progressive loss of flexibility due to the deposition of solid elements in them, the minerals of various kinds (such as, carbonate and lime phosphates). As the body grows from youth, the bones grow, the cartilagenous materials change to bone, epiphyses knit to their respective long bone shafts, and the density of the tissues increases.

The composition of bone includes from 32 per cent to 84 per cent of solid matter according to the type of bone and its age. Approximately, the density of bone changes from 1.87 to 2.00 in the first 30 years. Amar[1] summarizes Wertheim's findings to show, for example, that Young's modulus for a 30-year-old man is 1819 Kg./mm.^{2} and in a 74-year-old man is 2638, meaning that the resistance to bending is 31 per cent greater. The breaking stress for the same two subjects is 10.50 Kg./mm.^{2} and 7.30 Kg./mm.^{2}, respectively, which is a weakening of 31.4 per cent. These figures suggest considerable caution for older men in taking exercises in which the joints are extended to a maximum or in which the tissues are exposed to sudden shocks.

Similar trends with even greater implications are also observed for muscle tissue. Wertheim observed for muscle on fresh corpses that Young's modulus was 1.271 Kg./mm.^{2} (1 yr.), 0.352 (30 yrs.), and 0.261 (74 yrs.) indicating that muscle is more elastic in a one-year-old child than in older persons. The difference between the child and the old man is only 80 per cent! Muscle also has greater resistance to breakage in youth than in old age: .070 Kg./mm.^{2}(1 yr.), .026 (30 yrs.), and .017 (74 yrs.), or approximately 63 per cent greater at one year than at 30 years, and 53 per cent greater at 30 years than at 74 years. Older persons are, therefore, particularly susceptible to ruptured muscle fibers when exposed to sudden jerks, shocks, or when full-range exercises are taken too forcibly. All of these injuries heal with adhesions which makes flexibility still poorer. The great importance of graduated programs of flexibility exercises and wise direction of them is very apparent.

Benson[2] has pointed out the basic diagnostic value of flexibility tests, working on athletes with injured ankle and knee joints. He concludes that an injured joint invariably results in some loss of flexibility, although proper therapeutic procedures can reduce the loss. The significance of this work is that flexibility tests usually show up previously injured joints. Usually, a subject being tested will favor a previously injured member, or will not force an injured joint to the limit because of pain. Swollen joints, deformed joints due to previous injury, or tissues having adhesions because of previous injury will all reduce the flexibility test scores, although a specific diagnosis cannot be made so superficially. From this point of view flexibility tests should be viewed as "screen" tests.

Dr. R. Tait McKenzie has pointed out important relationships of flexibility tests and exercises to disabled war veterans. After the First World War he directed much of this rehabilitation work. A variety of *flexímeters* and the *Falconer arthrometer* were developed to aid diagnosis and to motivate improvement.[21, 22]

FLEXIBILITY EXERCISES FOR CONDITIONING

Athletic coaches have long had the idea that pre-season conditioning composed of graduated progressive programs of strength and flexibility exercises will toughen the tissues and prevent injuries. Such exercises are widely used for conditioning in football,[19] skiing, wrestling, boxing, and many sports. The assumption in this work is that the tissues may be prepared to bear stress by gradually increasing the load upon them, alternately with rest. Theoretically, *Wolff's Law* may be quoted in support of this situation: [36]

> The internal conformation and external shape of a bone changes with any constant change in the stress applied, so that it will be best adapted mechanically to resist the stress.

The proof of this law was advanced by Koch in his classic work upon the femur wherein he was able to show a remarkable adaptation of every part of the femur to the mechanical requirements due to the load on the femoral head. Steinhaus[30] in a review of the literature supports this position with observations that exercised bones get heavier than their unexercised mates. He quotes the studies of Kohlrausch who presented X-ray data to show that the bones in athletes show definite changes to resist the unusual stresses encountered in specialized activities.

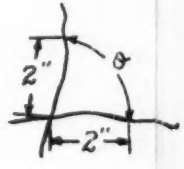
Girdlestone[13] quotes Keith in discussing the function of ligaments and points out that ligaments invariably elongate when a continuous burden is placed upon them and that they come into play when the muscles which surround and guard the joints are forced beyond the compass of their normal stretch. They state that ligaments are composed of fibrous tissue and just like muscles they can be educated to assume a greater function under stress, implying that ligaments can be strengthened by working them alternately with rest. Such deliberate conditioning through strength and flexibility exercises does seem to prevent injuries in combat activities, or those activities in which the body must meet severe stress during collisions, sudden twists, falls, and maximum speed and endurance efforts, otherwise, "pulled tendons" or "pulled muscles" are common.

FLEXIBILITY TESTS

A number of writers have used flexibility tests, such as Benson[2] and McKenzie.[21] A number of experiments have been conducted with four rather simple and objective tests devised by the writer. A number of students have used these in their studies.[12, 17, 31, 35] The results referred to in this paper and some reported in the literature have been obtained with the *Trunk Flexion, Trunk Extension, Shoulder Elevation,* and *Ankle Flexibility* tests. These are the only tests described in the literature at present which have been standardized to any extent and for which some norms are known: [6, 7, 8, 9]

NAME.....

ADDRESS.....

Items	Technique of Measurement: Instrument	Technique of Measurement: Conditions or Locations	Subjects' Measures	No. of Cases		.1	.6	1.2	2.3	4.0	6.7	10.6
Trunk Flexion Foreward	Slidingwood caliper	Long sitting position with arms in neck firm position. Place feet 18 inches apart. Bend forehead downward and foreward as far as possible keeping the knees straight. Measure distance from forehead to table.	in.	647		23.18	21.33		19.48		17.63	
Trunk Extension Backward	Slidingwood caliper	Lying on stomach with hips held fixed by assistant. Arms in neck firm position. Lift head and chest upward and backward as far as possible. Legs straight and flat on table throughout. Measure distance from chin to table.	in.	551		3.0	4.6		5.4		6.6	
Shoulders	Slidingwood caliper and meter stick	Lying on stomach. Arms straight and shoulder width apart. Hold meter stick and keep chin on table. Raise stick up as high as possible with wrists and elbows straight. Measure distance from stick to table.	in.	576		3.0	4.54		6.09		7.63	
Average Ankle Flexibility	Paper, long pencil, board —18" x 18" x 1" and protractor	Long sitting position. Keep heel stationary. Trace top of foot inaximum extension and flexion positions keeping pencil perfectly horizal. 	deg.	707		23.56	29.0		34.51		39.98	

—3 σ —2½ σ —2 σ

20 30

COLLEGE MEN

SIS

Percentile Rating Scale

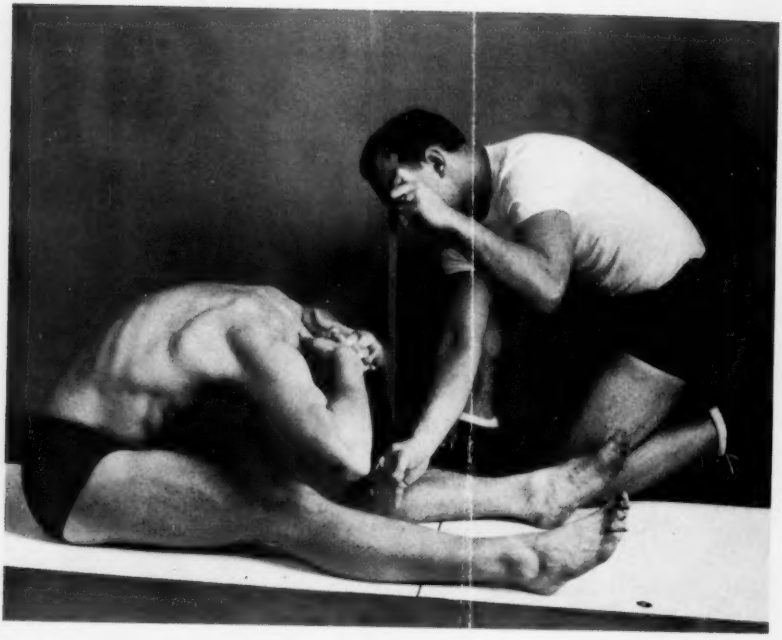
0.6	16.9	22.7	30.9	40.1	50	59.9	69.2	77.3	84.1	89.4	93.3	96.0	97.7	98.8
	15.78		13.93		12.08		10.23		8.38		6.53		4.68	
	7.83		9.64		11.45		13.26		15.07		16.88		18.69	
	9.18		11.4		12.9		14.76		16.62		18.48		20.34	
	45.46		50.93		56.41		61.88		67.63		72.83		78.30	

$-1\frac{1}{2}\sigma$	-1σ	$-\frac{1}{2}\sigma$	0	$+\frac{1}{2}\sigma$	$+1\sigma$	$+1\frac{1}{2}\sigma$	$+2\sigma$
	40		50		60		70

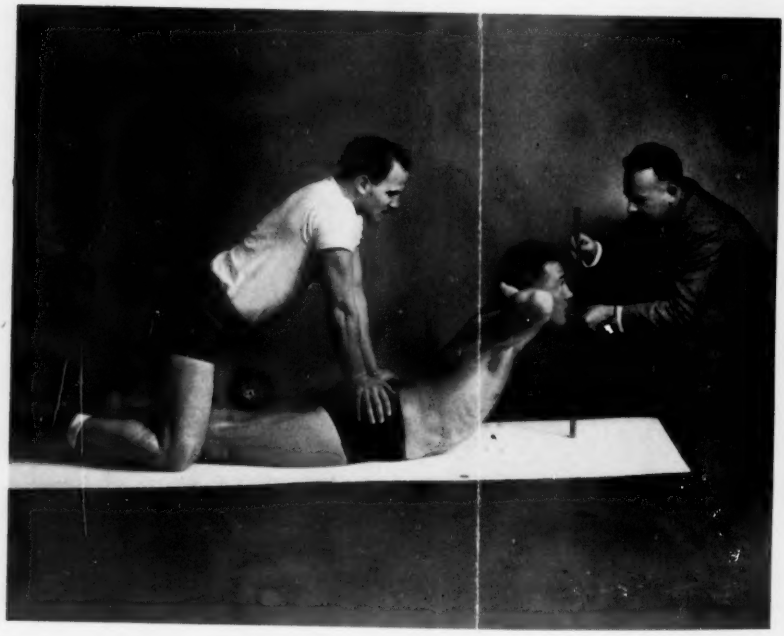
.7	98.8	99.4	99.9	PER-CEN-TILES	COMMENTS
4.68		2.84	.98		
18.69		20.50	22.31		
20.34		22.20	24.06		
78.30		85.78	89.26		

$+2\sigma$ $+2\frac{1}{2}\sigma$ $+3\sigma$

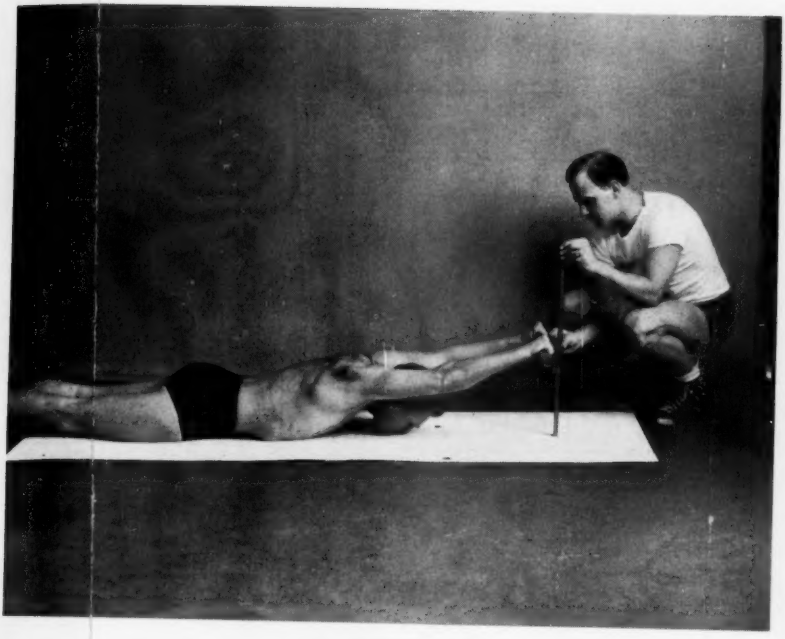
70 80 .....Average Percentile



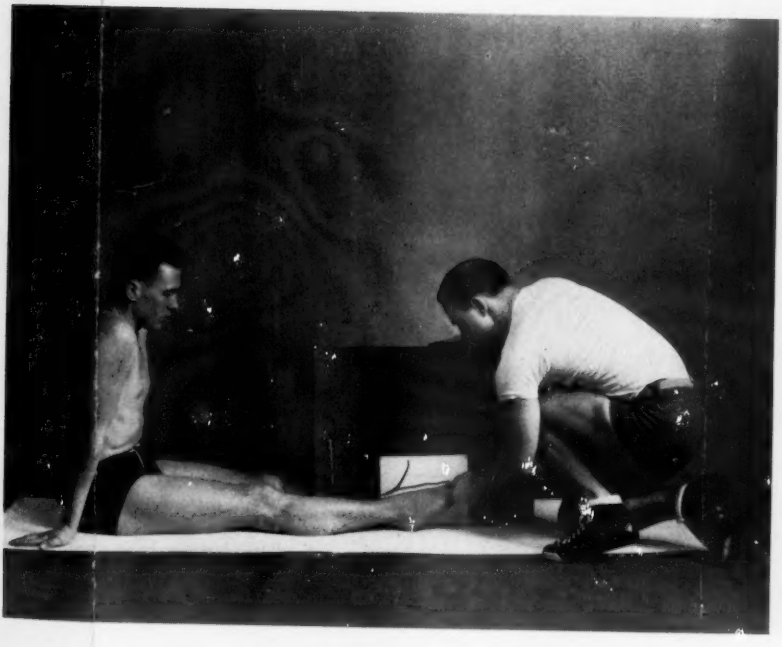
1. Trunk Flexion Forward



2. Trunk Extension Backward



3. SHOULDERS



4. AVERAGE ANKLE FLEXIBILITY

TABLE II

INTERCORRELATIONS BETWEEN THE FLEXIBILITY TESTS

Tests	Trunk Flexion	Trunk Extension	Shoulder Elevation	Ankle Flexibility
Trunk Flexion	.958	.212	.149	−.269
Trunk Extension	.212	.715	.358	−.041
Shoulder Flexibility	.149	.358	.850	.137
Ankle Flexibility	−.269	−.041	.137	.728
Average T-Score Flexibility (The Four Tests)	.652	.638	.553	.688

Trunk flexion does not correlate very significantly with the other three tests, nor do *trunk extension* or *shoulder elevation* correlate highly with any others except the self-tests. The tests are, therefore, fairly specific which means that flexibility is not some general quality which causes all tests of it to vary alike. Each major joint has a high degree of specific condition of its own. The average flexibility (average of the four T-Scores) correlates .074 with the McCurdy-Larson Organic Efficiency scores, indicating that flexibility does not seem to be systematically a function of circulatory-respiratory condition but something definitely more structural in nature.

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CHAPTER VI

Strength as an Approach to Physical Fitness

By Thomas K. Cureton and Leonard A. Larson

Interpretation of Strength as an Aspect of Fitness

Modern writers on Health and Physical Education stress the health values in *body building* achieved by means of hard muscular work. McCloy [60] in an article, "How about Some Muscle?" expresses the philosophy of the body builders. Rogers [71, 76] has been foremost in making some very positive statements about the relationship between strength tests of maximum effort and various aspects of physical fitness, for instance:

> The positive and very high relation of muscular strength to general health, physical fitness, or capacity for activity can hardly be questioned. With no strength there can be no physical activity; moreover, when muscular strength is low, all other life functions are handicapped. . . . Practically every change in the condition or functioning of the vital organs has a corresponding change in the condition or functioning of voluntary muscles. . . . It is the prime function of respiration, circulation, digestion, elimination, and even cerebration, to maintain the effectiveness of muscles as means of locomotion and manipulation.

McCloy [68] supports this position with a slightly different viewpoint:

> Each individual is required to carry or support his bodily weight from morning to night. He must do this with the musculature he has. It is known that a muscle that is too weak for its task works at a lower efficiency than does one that is adequately developed. Hence, an individual who is markedly underdeveloped is working inefficiently, so far as his muscles are concerned, and is suffering greater fatigue, both locally and generally. He has less energy with which to approach his tasks, suffers more from fatigue toxemia, and works under a greater nervous strain. Hence, in addition to its indications as to general "medical" condition, the strength tests in the form of the physical fitness index tell much about the individual's *general* fitness for living and working.

Mesomorphic types, with high muscle, bone, and connective tissue development, according to the philosophy of Rogers and McCloy, should be the dominantly healthy types. Physicians, nurses, and physical directors are apt to judge them the most healthy and robust people. It is obvious that bodily vigor is synonomous with ability in the strength or power activities. The individuals with a great deal of natural ability in static endurance strength tests, chinning, push-ups, press-ups, weight lifting, wrestling, vertical jumping, broad jumping,

high jumping, medicine ball throwing, weight throwing, sprinting, and strength types of apparatus exercises have abundance of muscular force and capacity to release it powerfully. It is common judgment to believe such types to be healthy. They probably would be so voted by any expert jury.

Since the various body build studies have shown relatively higher incidence of morbidity and mortality in the extreme *Ectomorphic* and *Endomorphic* types, with relatively better records for *Medial* and *Mesomorphic* types, there would seem to be broad supporting evidence to substantiate the claims of the muscle builders. There is a strength type, easily recognizable to body mechanics experts. The structural pattern of a *Mesomorph* is fixed to a great extent by heredity and there are marked limitations to changing other extreme types into Mesomorphs. So far, the evidence is very meagre to support claims that it can be done. Such studies, aiming to measure the change in body type and correlative changes in various types of physical fitness indices, induced by planned periods of training, would seem to be among the most important to be pursued. Schwartz, Britten, and Thompson [88] reported marked changes in strength and vital capacity as a result of training exercises. Such evidence is basic to understanding what may be accomplished in rehabilitation programs. Relatively little is known about the concomitant variation of various types of immunities and health indices with improvements or losses of strength. Individual case records are, therefore, highly important. Forms for such records have been devised by Clarke.[17]

STRENGTH TESTING AND FITNESS PROGRAMS

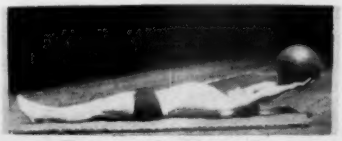
As early as 1702 there were reports of studies on the physical strength of man. Amar [5] states that the French anthropologists invented strength dynamometers and calls attention to the studies of De la Hire (1686–1703) and Amontons (1703). Coulomb (1821) published studies in this field and by his time a number of inaccuracies common to strength testing were known. It was known that the dynamometrical strength increased approximately as the square of height and that weight varies approximately as the cube of height. A law of development linked large bones to large muscular development. Exceptions were recognized, the large man was not always the strong man on dynamometer tests, this fact leading to interest in the tests and ultimately to a study of the internal leverages and muscle mechanics for underlying basic explanations of relatively high strength for size and weight. Quetelet contributed much to this early work.

Bovard and Cozens [9] review the American inauguration of this program beginning at Amherst in 1861. Dr. Dudley A. Sargent began the systematic measurement of Harvard students in 1880 for the purpose of determining physical standards for the American college stu-

A GROUP OF STRENGTH AND BODY BUILDING EXERCISES.

MEDICINE BALL EXERCISES

FOR THE SHOULDER DEPRESSORS, QUADRICEPS AND THIGH FLEXORS.



FOR THE SHOULDER DEPRESSORS.

FOR SHOULDER DEPRESSORS AND ABDOMINALS.

FOR THE THIGH EXTENSORS.

FOR THE BACK AND NECK EXTENSORS.

FOR THE LOWER BACK

dents. Out of this work developed the *Intercollegiate Strength Test,* consisting of a battery of tests for the strength of the back, legs, right and left grips, pull-ups, and push-ups. Vital capacity was also measured. The test was given in a number of the larger universities. Sargent [85] wrote a review of this work in 1913 covering "Twenty Years Progress in Efficiency Testing." A few years after, in 1921, he described what to him was the best efficiency test, "The Physical Test of a Man." [83]

Seaver [86] describes some of this early American work, particularly the work of Dr. J. H. Kellogg, who developed the universal dynamometer following the principle that a person could be accurately rated in strength only if all the important muscle groups were tested, a single group indicating very little. Strength graphics were developed with the mean line determined from the average of 500 college men. Seaver summarized the findings which developed from this program:

> The relation between bone size and muscle size varies in different types of men, viz., in the short person the muscles have a much larger proportional size than in the tall person. This has been demonstrated before in other ways and formulated into a law that a working muscle varies as its cubical contents. Second—that there is a direct ratio between exercise and bone growth. Third —a high development seems to declare itself in more increase of depths than of breadths. Fourth—that there is a direct ratio between the size of muscles and the capacity of the lungs. Fifth—that girth of waist increases with chest and hips but not in the same proportion. Sixth—that high nutritional power is essential to high development. Seventh—that muscular and nervous strength increases in greater proportion than other items; so we may infer that high strength tests indicate physical welfare."

Rogers [72] revived this program with the publication of his dissertation in 1925. His work has been widely applied and norms are available.[73, 74, 75, 76, 77] Thousands of young men and women have been interested to work to build stronger bodies through incentives derived from the testing program. A notable example of this has been Crampton's application of the strength idea to build interest in fitness among the Boy Scouts.[22] A wave of weight-lifting interest has swept over the whole nation, all in the direction of building more strength and better bodies.

CONFUSION OVER THE MEANING OF THE TESTING RESULTS

Hundreds of studies have developed showing the results of the strength testing program. Confusion has resulted in the interpretation of these and certain errors in norming and in testing have been brought to light. It has been exceedingly hard to *prove* the assumed relation between the strength test scores and health indices, except in the area of power types of athletic performances. Some favorable evidence has been cited in the reports of Smiley and Chamberlain,[89] Hernlund,[88]

Rogers,[71] Wellman,[96] and Osgood [69] but as a whole these studies have been disappointing with negative studies appearing in greater abundance including those of Anderson,[8] Marker,[56] Collins,[19] Rudert,[80] Schwartz, Britten, and Thompson,[88] Hyde,[42] Cureton,[23] and Roulhac.[79] Little has been shown about health and the P.F.I. has been misinterpreted by school administrators in their zeal to show positive results of their programs. The studies just cited show that the P.F.I. does not correlate well with tests of running and swimming endurance, circulatory-respiratory indices, flexibility, posture, or specific types of disease immunities. Since the studies are not conclusive, and some of the difficulty may be due to the inadequacy of the correlational techniques to deal with data which reverse in interpretation within a continuum series, the relation between strength fitness and other types of fitness remains to be demonstrated in further research. Physicians have sensed the inadequacy of maximum strength as an indicator of health, these objections being summarized by Keene [45] and in an editorial in the official journal of the American Medical Association: [6]

> It may be safely concluded that current scientific opinion cannot grant that physical fitness may be deduced from one set of measurements alone or that muscular strength is either an accurate or a valuable index of physical fitness.

CLASSIFICATION OF THE STRENGTH PROGRAMS

Strength Fitness Programs may be roughly classified according to purpose:

1. *Positive Developmental and Corrective Exercises.*—Gemme,[32] Gruenberg,[35] LaBree,[47] McCurdy,[65, 66] Bukh,[10] Camp,[12] Knudsen,[46] Langmack,[49] Staley,[90] Sumption,[94] and Phelps and Kiphuth.[70] (Illustration)

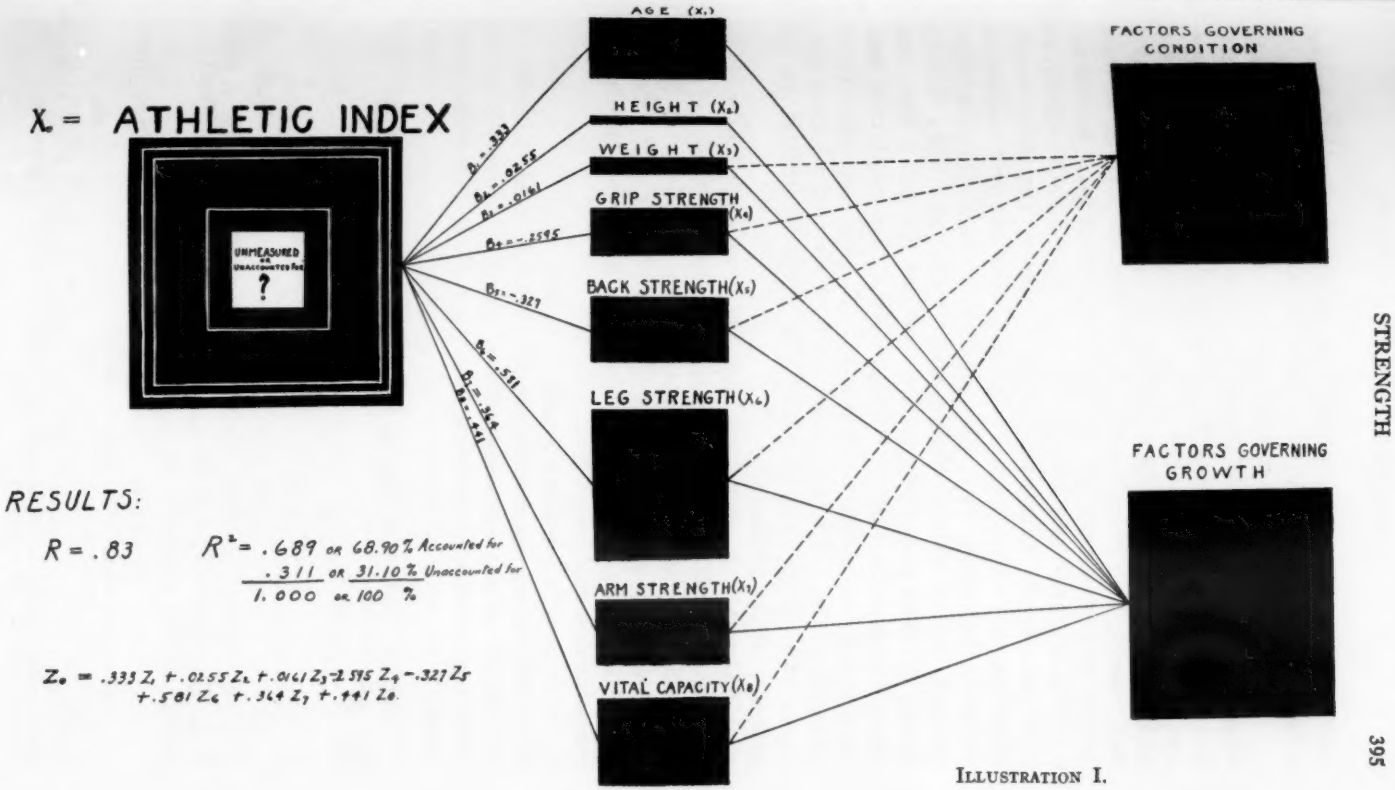
2. *Testing of Strength for Classification and Guidance.*—Alden, et al.,[2] Anderson,[7, 8] Allen,[3] Burr,[11] Cozens,[21] Dunder,[26] Elbel,[27] Elder,[28] Martin,[58,59] MacCurdy,[53] McCloy,[62] Norris,[68] Osgood,[69] Rogers,[72, 73, 74, 75, 77] Sargent,[84] Seaver,[86] Larson.[50]

3. *Case Study Histories or Profiles for Relationship to Health.*—Kellogg,[86] Clarke,[17] Rudert and Cureton.[80]

4. *Group Progress Recording to Show Improvement or Retrogression.*—Carter,[14] Chesky,[15] Clark,[16] Whiting,[98] MacKenzie,[54] Jones,[44] Wrightstone,[100] Wylie,[101] Malcolm,[55] Clarke and Bonesteel,[18] Albany Physical Education Staff,[1] Hernlund and Barfield,[39] Jack,[43] Laveaga,[51] MacKenzie.[54]

RELATIONSHIPS OF STRENGTH TESTS TO ATHLETIC PERFORMANCE

Strength is Dominant in Power Types of Athletic Performance.—The strength or power indices of Rogers,[74] MacCurdy,[53] McCloy,[61] Cozens,[21] and Larson [50] are all valuable devices for measuring strength



RESULTS:

$R = .83$ $\quad R^2 = .689$ or 68.90% Accounted for

.311 or 31.10% Unaccounted for

1.000 or 100 %

$$Z_0 = .333 Z_1 + .0255 Z_2 + .0161 Z_3 - 2595 Z_4 - .327 Z_5 + .581 Z_6 + .364 Z_7 + .441 Z_8.$$

ILLUSTRATION I.

and power capacity from which dynamic types of athletic performances may be predicted with considerable efficiency.

A multiple regression solution of all of the items involved in the Rogers Strength Index Battery gives a multiple R of .83 including age, height, weight, the back strength, leg strength, hand grips, push-ups, and pull-ups. (Illustration I.) In the relative *net* contribution of each of the items to the four item Athletic Index (composed of 100-yd. dash, running high jump, running broad jump, and standing bar vault), it may be seen that the strength items contribute 64.45 per cent compared to 11.08 per cent for age, 19.45 per cent for vital capacity, and 2.26 per cent for height and weight combined. The intercorrelations range from .39 to .81. Rogers' original correlations were used from the Montclair schoolboy data. The multiple R without age, height, or weight is .77. In Rogers' original work the Strength Index (S.I.) correlated .73 with a 152-yd. run for time and .80 with a 304-yd. run. Using college data, the S.I. correlates .67 with a 20-yd. crawl sprint, .34 with a 40-yd. sprint, .08 with a 60-yard. sprint, and .08 with a 100-yd. sprint. The P.F.I. correlates .10 with the 100-yd. crawl sprint. Again with college data, the hand grip strength correlated .001 with push-ups on the parallels.

MacCurdy [53] developed a *Force Index* with elimination of vital capacity and with the arm strength taken as a combination of pushing and pulling in the horizontal plane rather than reflected in chinning. This correlated .52 with Cozens' Test (modified) as a criterion. A *Power Capacity Index* was derived by multiplying the force index by the vertical jump:

$$\text{Power Capacity} = \text{F. I.} \times \text{V. J.}$$

This combination (not exactly true physically) has a validity coefficient of .68 with the same criterion. McCloy,[63] Cureton,[25] and Van Dalen [95] demonstrated that vital capacity is of little use in the strength battery.

McCloy [61] suggests that in scoring chinning the following formula be used:

$$\text{Total Strength} = 1.77 \text{ Wt. (lbs.)} + 3.42 \text{ (No. Chins)} - 46$$
$$R = .934 \text{ with estimates of total strength.}$$

Cozens [21] presents the proof that the Rogers S.I. correlates .567 with his General Athletic Ability Test * using 250 entering college men. He suggests that General Athletic Ability may be predicted from a short battery composed of:

$$\text{G.A.A.} = 1.04 \text{ (No. Chins)} + 1.08 \text{ (No. Dips)} + \text{Height (inches)}$$
$$\text{(roughly)} = \text{Chins} + \text{Dips} + \text{Height}$$
$$R = .686$$

* Composed of: (1) baseball throw, (2) football punt, (3) bar snap for distance, (4) standing broad jump, (5) dodging or maze run, (6) 300-yard run, (7) dips, T-scores weighted and combined.

Using ten strength tests as a criterion, Cozens was able to reduce the battery to five with a multiple R of .982 in predicting the criterion: (college men)

$$\text{Total Strength} = 4.0\ (\text{Chins}) + 7.8\ (\text{Dips}) + .053\ (\text{Leg Lift}) + .356\ (\text{Knee Resistance}) + 5.4\ (\text{Height}) - 203$$

Larson [50] reviewed the studies on strength and established a fifteen item All-Round Athletic Ability criterion. He tried various combinations and came to the conclusion that for all practical purposes a combination of chinning, dipping, and vertical jumping is as good a combination as any and is easiest to administer. It gives a correlation of .685 with the criterion compared with .591 for the Rogers S.I. and .521 for the MacCurdy Power Capacity Test. In a factor analysis Larson concludes that "Dynamic Strength" in which the body is moved clusters very differently from "Static Dynamometrical Strength" and is about three times as valuable in predicting the criterion of All-Round Performance.

LIMITATIONS OF STRENGTH TESTS AS INDICATORS OF HEALTH AND PHYSICAL FITNESS

The relative proportions of skill, effort, organic condition of a circulatory-respiratory type, body build factors, and absolute strength entering into strength tests like those described above are relatively unknown. Most of the evidence that these tests correlate with physicians' judgments of health status (robustness, physical development, and freedom from disease) favors the direct strength indices for classified body type groups rather than the P.F.I. scores (Rogers Physical Fitness Index). Some of the reasons for this may be explored, although much more evidence is needed to make a final statement. No doubt, if an individual's P.F.I. score improves, it indicates some change. What changes, and whether the change is for better or worse when related to organic efficiency criteria, remains to be demonstrated. Certain difficulties may be shown which lead to questioning the assumption that the P.F.I. scores or their change up or down can be interpreted well enough to base a health program upon them.

Difficulty with Norming.—There is no direct way to measure the *absolute* † muscle force in any living human being. This force is transmitted to the body proximally and to the limbs distally but at greatly varying percentages of efficiency according to the exact leverage systems involved and the angle at which the muscle acts on the bone. Studies

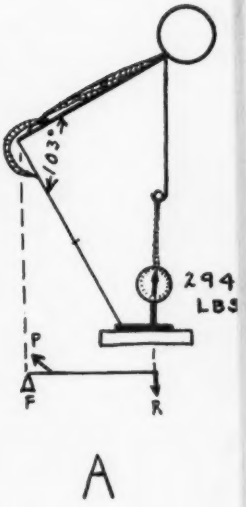
† *Absolute* muscle force is the force due directly to the composite contractile force of the muscle fibers transmitted longitudinally in the direction of the attached tendons. *Internal Leverage Strength* is the strength of the muscle acting through its distal or proximal tendon to move an attached lever and the weight connected to it. *External Applied Leverage Strength* is the force exerted on a definite object at a point outside of the body.(99)

by Marker [57] (Illustration II) demonstrated with twelve men that in the Back Lift dynamometer test an average angle at the hips of 103° gave an average strength of 294 pounds, whereas, an average angle of 156° gave an average strength of 379 pounds, an increase of 28.9 per cent. (Illustration II-A) Likewise, with the Leg Strength Test an average angle of 145° gave an average strength of 295 pounds, whereas, a change of the angle to an average of 102.5° gave strength of 490 pounds, an increase of 32.2 per cent (Illustration II-B). Carpenter [12] has demonstrated similar results. Since proportions in the trunks and limbs vary, it has not been possible to standardize conveniently the results in the tests reported to date. It is quite possible that the variations in scores reflect such angular variations rather than true differences in fitness.

Using college men, Hunsicker [41] has shown a correlation of +.469 between chinning and the speed of chinning. All the results reported to date have been unstandardized regarding this factor and the variations in scores may reflect differences in physiological rhythm which affect the efficiency of the performance, rather than quality of condition within the muscles. Hubbard,[40] for instance, points out that efficiency is much greater when movements are timed to take maximum advantage of ballistic action. Some individuals know how to do this and others do not, possibly a function of experience in the event.

Stiles [93] points out that the "all-or-none" principle operates in muscular efforts of this kind. When the fibers contract, they contract all the way, the efficiency varying with the number of them acting and the quality of the forces released. The former is a function of neuromuscular learning, the latter a function of the nutritive state of the fibers and the efficiency of the motor end plates in distributing the stimuli to the fibers. It is thought that the development of the neural efficiency is a function of practice of the event. Disuse and fatigue destroy the neural and nutritive efficiency. Great strength for the size of the muscle and skeletal build possibly represents the fact that a high proportion of the fibers contract efficiently. It is doubtful that this condition correlates perfectly with the many other specific types of condition related to immunity, to the autonomic nervous and muscular systems, to the condition of the heart and vessels, to circulatory efficiency in the viscera, etc. The bulk of muscle hardly gives a guide to strength performances. It may be a highly valuable factor in evaluating nutrition, however, as is suggested by Franzen's studies.[30]

Measured amounts of muscle correlate very low with strength test scores or with P.F.I. ratings. Hunsicker [41] reports a correlation of —.115 with the *Squires Muscle Girth Index;* a correlation of .268 with girth of the upper arm, .176 with thickness of the Biceps muscle, .104 with volume of the whole arm. The study by Cox[20] at Iowa is a similar one. Rudert [80] demonstrated that the P.F.I. ratings did not coincide with



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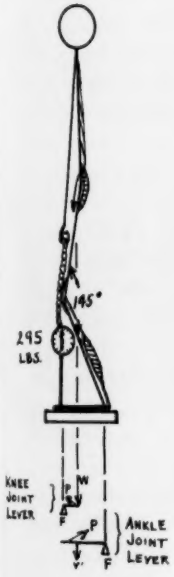

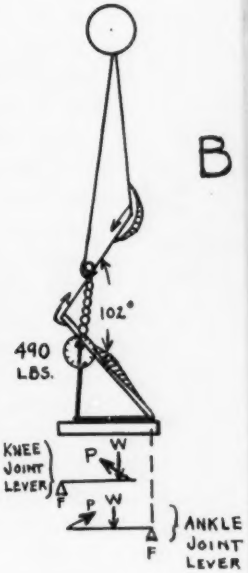

ILLUSTRATION II.

physicians' judgments of the gross physical development and nutritive condition of Junior High School boys. There is a tremendous *educability* factor in strength tests. In studies by Elder,[28] Burr,[11] and Seitzer,[87] strength tests increase from day to day as much as 30 per cent in a week, without introduction of strengthening exercises. In studies which show increases in strength from month to month it is questionable whether this is due primarily to educability to the tests, improved differentiation and efficiency of the motor end plates permitting more muscle fibers to be used, or whether there are changes which have a more direct "fitness" connotation, such as, changes in the muscle bulk and its nutritive state, changes in blood condition, or other organic functions which indicate a shift toward better fitness.

Thus, the difficulty of reasoning back from *Externally Applied Leverage Strength* to infer any particular "fitness" state, is a hazardous procedure, fraught with many errors in individual cases. Only as men are compared who have exactly the same skeletal proportions and leverages will it be possible to come closer to interpreting strength scores, Much of the confusion manifest is due to using bases for norming which are relatively meaningless in terms of health. Certainly, within the age band of 17–35 years, age and weight are not the most meaningful, nor do they vary enough with strength to justify being used as bases. Constitutional type groupings will probably be shown to be better bases. Griffitts[34] has summarized other difficulties with the strength norms. There is no good way now known to predict what the strength of an individual *should* be, so that his actual strength may be divided by it, as is done in the P.F.I. norming procedure. This presumes knowing a person's specific leverages involved in the test taken, and other controls which are usually neglected. Nor is it effective to compare a person to a group norm, whether this be an average, a straight regression line, or a curvilinear regression line, but this is common practice. The residuals need to be interpreted against meaningful fitness criteria and to date this has not been done. What an individual's P.F.I. means above or below an average is not certain but it has been shown that heavy Mesomorphic types with splendid muscular development are penalized by being rated much too low on the norms now published, and the extreme Ectomorphic individuals rate the highest in spite of the fact that they represent the poorest health risks other than extreme Endomorphs.

Also, little correlation has been shown between a wide variety of performance and fitness indices and the P.F.I., using Springfield College data. In case studies made by the writers the P.F.I. correlates practically zero with the nutrition measurements of muscle, —.200 to —.400 with measured adipose, and from —.150 to —.400 with skeletal build measurements. A typical case is described below:

CASE ANALYSIS

Subject .....M.C. P.F.I..... 67 Weight.....152

No. 3 (Roulhac series) Height.....5'-10"

Items	Raw Scores	Percentiles
Rogers' P.F.I.	67	5.7
Rogers' S.I.	1395	3.9
Track and Field Ability	Composite TS*	10.9
Cozens' Athletic Ability	253	2.0
Gymnastic Ability	Composite TS	43.8
Brace Test	90	93.0
Aquatic Ability	Composite TS	26.1
Posture	Composite TS	40.7
Flexibility	Composite TS	54.0
Circulatory-Respiratory McCurdy-Larson Test	McC-L Index	80.9

* Indicates T-Score.

The study of many individual cases of healthy, powerful, and efficient young men of college age has shown a wide range of P.F.I. scores, practically impossible of interpretation in terms of any one standard of fitness. It was found that the average P.F.I. of Springfield College seniors was 82.53 per cent in 1932. Study of the data presented on men of this type (see Chapter I, Table V page 320) shows that they are a highly selected, well-built, and adequately nutrified group. It is obvious that the published norms do not fit them. The larger men rate the lowest and the smallest men rate the highest. The varsity swimmers averaged 84 per cent, the track men 84 per cent, the boxing team 85 per cent, the soccer team 85 per cent, the cross-country team 96.8 per cent, the gym team 102.8 per cent. Interchange the men on these teams, meaning put the track men into swimming, would their performance efficiency be the same? The New England Intercollegiate 440-yard swimming champion in 1933 and 1934 (C.S.) had a P.F.I. of 75 per cent, the poorest swimmer in indurance on the team (G.A.) had a P.F.I. of 93 per cent. The most outstanding baseball and football player (G.M.) had a P.F.I. of 85 per cent and made a big league professional ball team after graduation. The New England boxing champion (J.C.) was 85 per cent, the best sprinter on the track team (R.W.) was 80 per cent, the best shot putter (W.H.) was 54 per cent.

In repeating this work for several years very similar results were found. The 1937 freshman class averaged 89.3 per cent, the seniors averaged 85.6 per cent, although the differences between these groups in favor of the seniors being more skillful and trained are unquestionable. These difficulties agree with those encountered by Messer,[67] who also found that the light-weight men qualify in the highest brackets and that the heavier men had the lowest P.F.I.'s.

In Rudert's study [80] there are many case analyses made on junior high school boys. Working closely with three experienced school physicians, Rudert came to the conclusion that the P.F.I. was an unreliable index to the robustness and gross tissue symmetry of the individuals. There was no evidence that a high P.F.I. meant a high health status as judged by these physicians, or that a low P.F.I. meant a low health status. For individuals falling outside of the 50-percentile range, an inverse relation seemed indicated. The extreme ectomorphic types had the highest P.F.I. scores and some of the mesomorphic types had very low scores. On the other hand, the Rogers Strength Index gave a much better classification which agreed fairly well with the physicians' judgments.

CONCLUSIONS

1. Strength is one type of physical fitness which is high in mesomorphic types.

2. Strength can be improved within limits of physical build but extreme changes from one major type to another are not to be expected.

3. Much confusion exists over the interpretation attached to strength scores, not all of which is reconcilable with the research evidence at hand.

4. The various strength batteries of Rogers, MacCurdy, McCloy, Cozens, and Larson correlate from .500 to .700 with composite batteries of dynamic athletic activities and are useful devices for classification of groups.

5. Specific types of skills, such as, swimming, tennis, golf, riding, shooting, etc., are not predictable from strength scores with a high degree of efficiency.

6. Strength scores are functions of external leverage, internal leverage, educability, psychical states, constitutional type, neuromuscular conditioning, and nutritive state in the muscle fibers. What they mean exactly is difficult to tell in an individual case.

7. Strength scores do not correlate well with muscle girth or thickness measures, circulatory-respiratory measurements, flexibility scores, posture scores, Brace motor ability scores, or incidence of disease (within the limits of the data at hand). Epidemics sweep through the strong as well as the weak.

8. Specific case studies show that the Rogers P.F.I. (Physical Fitness Index) is not normed so that it is meaningful to the authors' concepts of health. It is a hazardous device upon which to base a program as a single indicator of "fitness."

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CHAPTER VII

Motor Fitness

(Athletic Performance as Indicators of Fitness)

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MOTOR fitness is the final criterion through which all other elements of physical fitness are seen and measured in man. How continuously and efficiently he performed his daily work in industry, on the farm, in the armed forces or in athletic performances, was at one time the only criterion that man had of physical fitness. He might know little or nothing about scientific facts of body structure, physiology, or functioning of the organs, strength tests on the dynamometer, or organic efficiency tests. But he could understand an outstanding performance displaying power, speed, and endurance.

Observations in all activities of life indicate that there are a great variety of motor abilities, both in kind and within the activities themselves. What are the factors that make for these distinguishable differences? As in academic pursuits, we recognize in subjective and objective ways that men have different degrees of educability. This is recognized in the differences between the "dub" athlete and the accomplished professional or high degree amateur who perfects himself in tennis, baseball, or other highly skilled event.

Both the physical and social aspects of sports are of equal importance. One cannot function without the other. Physical educators and coaches are prone to place too much emphasis on strength, speed, and skill elements. "The steps and laws for learning habits and skills are more established than are the procedures for attitude formation. The notion prevails that attitudes just grow without any direction or power over them on our part." [61] Other professional groups that emphasize the social aspects of life and place too little emphasis on physical aspects of life miss just as evidently the "whole man" aspect as the purely physical emphasis does.

But, nevertheless, physical educators when testing for elements in motor skill performance, leave out important considerations, such as personality traits—aggressiveness, cooperativeness, fortitude, quickness of learning, educability as applied to game situations. Even sportsmanship may have some effect on performance in the game and affect the results one way or another. Studies of the total situation indicate in some athletic situations of team games that skill may have as low an estimate as 25 per cent to 40 per cent of the total situation on the college and high school levels. Studies at Springfield College on soccer players seem to indicate this.[47, 86] It would be true in a similar way in football, lacrosse, baseball, basketball, and other team sports. But also in sports

of individual performances such as in track and field events, swimming, tennis, boxing, and wrestling, the skill elements are integrated with emotional patterns that greatly affect performance. Recent industrial studies on production have shown that the skill performances are greatly affected by the attitude of the worker.

In many cases the coach of a team sport could not state all the details of why he selected certain men in preference to others, but his selection has usually rested upon a practical knowledge of constitutional psychology, involving as it does the whole man. Keen observation of the details of performance has been his guide. Some coaches are impatient with tests and measurements of the modern type, stating that they only need to see a man perform in practice or scrimmage to evaluate his relative worth. They realize that only parts of the whole are measured or tested. An organic circulatory test may test only a part of even the circulatory elements, or at least test them only under certain conditions; the usual test of skill, for instance in tennis, tests only certain parts of that skill. The modern methods of evaluating motor efficiency are through direct performance tests or through indirect tests or measurements of organic efficiency and general examination procedures of body type and present condition relative to that type.

Motor fitness is a complex. A number of factors enter into efficient performance whether it be mainly of strength, speed, endurance, or skill. There is not one thing alone, but the body type or structure, the chemistry, the mechanics, the organic functioning, and the emotional state, can all be considered as composing the elements that make for fitness in motor or skill performance. It is a *Gestalt*, resulting in the control of all the factors of strength and speed and endurance by complex psychic factors. These psychic factors culminate in what may be designated as "attitude" determining finally the excellence or lack of excellence in a performance. Emotional states of desire or purpose, primitive instincts (fear, love) may motivate to a higher or lower performance. It is the whole personality dynamically organized that results in motor fitness. Motor fitness is making the most of our constitutional make-up from structural, physiological, cognative, affective, and conative natures.

Measurable Factors in Motor Ability.—Motor efficiency or skill is composed of strength, endurance, speed, and the coordination or control of these elements for accuracy. Cozens [9] found, using ten test items as a criterion, that strength tests indicated athletic ability. A short battery yielded an R of .982. This battery consists of five tests properly weighted: back lift, leg lift, arm push, chins, and dips. The factors of age, height, and weight were found to be negligible in predicting performance. Coleman's studies [7] showed that he could predict the running broad jump, 60-yard dash, velocity index, running high jump, and the 16-lb. shot-put to a satisfactory degree, with measures of strength, velocity, height, and weight contributing.

Basic factors, or items that are fundamental to learning and skill accomplishment McCloy states are muscular strength, dynamic energy, ability to change direction, flexibility, agility, peripheral vision, good vision, concentration, understanding of the mechanics of the techniques of the activities, and absence of disturbing or inhibiting emotional influences. More specific factors in motor educability he summarizes as insight into the nature of the skill, ability to visualize spacial relations, the ability to make quick and adaptive decisions, sensory motor coordination relations of eye to head, hand, or foot; sensory motor coordinations related to weight and force, judgments of the relationship of the subject to external objects in relation to time, distance, direction; accuracy of direction and small angle of error; general kinesthetic sensitivity and control;* ability to coordinate a complex unitary movement; ability to coordinate a complex series or combination of movements which follow one another in rapid succession; arm control; factors involved in the function of balance; timing; motor rhythm; sensory rhythm; esthetic feeling. He indicates that a number of these are probably related.

All these recent studies indicate that power is one of the most important factors in many types of activity related to motor fitness. This is particularly true of actions where the force comes directly through striking with the hands as in boxing; pulling and pushing with the hands, arms, legs, and body, as in wrestling, running, jumping, swimming—especially in the shorter distances where speed or velocity is involved. In actions where the force is given through some mechanical aid, as in throwing the javelin, throwing a ball, in archery, or in the use of firearms, the degree of power varies greatly. The degree away from primitively applied power varies with the distance the contrivance has come down to us as a weapon in the hunt or in warfare. One of the latest achievements of man, the firearm, requires the minimum of power and endurance from the large muscles of the body, but a high degree of concentration, steadiness, and control in the direction of the missile. The emphasis is on small muscle coordinated movements with particular reference to hand and eye. As invention progressed to or passed a certain period, the discovery was added to sport, first as a necessity in training for warfare or the hunt and later used largely as an interesting psychological and physiological activity for sport or recreation. Industry presents a somewhat similar picture. With the development of machines came a lessening of need for pure muscular power and physical endurance and an emphasis on the use of the small muscles of the hand and eye. Most of the vocational pursuits of this day demand at the most only medium strength and for many people only medium or low coordination of large muscle movements. Unless sought for in recreational and sport fields or in gymnastics and dancing, the

* Dawson,[23] Brock,[5] and others at Springfield College have found majors in physical education markedly superior to non-physical education students in kinesthetic sensitivity and motor speed and control.

basic strength and endurance decline in the population. Subtly the processes of physical and nervous decay set in and man has again the problem of readjustment. It is in times of crisis—war, and even in some phases of economic difficulty—where a return to some of the more primitive aspect of life is necessary that the need for basic strength and endurance and skill—muscular and nervous—is shown to be so essential to survival. The emphasis on physical education by the present totalitarian peoples attests to the practical working of this basic fact.

Analysis of Motor Ability.—The studies which have aimed to analyze motor ability may be classified into two principal groups, (1) those which aim to determine "general," or "all-round" (cross-sectional) ability by means of batteries of items selected from a wide assortment of tests, and (2) those which aim to analyze "specific" ability in particular performance areas.

Logically, motor ability may be thought of as:

Motor Ability = General Capacity to Learn Motor Activities + Specific Areas of Learning Experiences (Swimming, Track and Field, Gymnastics, Tennis, etc.)

Little has been shown about the inherent capacity, or "ceiling limits" of learning in particular individuals but no doubt there are wide individual variations. Jones,[31] in one of the few available studies, failed to show that a "general" factor existed but the "tetrad" method used has been suspected of being inadequate. Future research will undoubtedly explore the nature of motor ability more fully in attempts to explain the wide differences in human performances. To determine the relative influence of the motor brain cells, the cerebellum controls, the motor end-plates, and the complex relations of leverage, timing, force, and experience is one of the most complicated of all scientific problems.

Experienced coaches know that training a man in one sport is usually not very good preparation for learning some other sport involving quite a different set of coordinations.

More progress has been made in analyzing *specific* skills. An example may be given in swimming.

Cureton's [21] studies in swimming made at Springfield College indicated that various factors of mechanics, endurance, and body build were related to performance. In the 20-yard crawl the following relative per cent contribution to the criterion were found: coordinating ability, 38.6 per cent; gliding efficiency, 14.7 per cent; leg kick efficiency, 12.1 per cent; strength (by Rogers' Strength Index) 5.5 per cent; arm stroke efficiency, 5.3 per cent; chest girth, 2.7 per cent; breath holding on flarimeter after 2 min. exercise, .8 per cent; diastolic blood pressure (sitting) .3 per cent. Physical size and body build, vertical floating capacity, horizontal floating capacity, flexibility, and pulse-rate items were practically negligible. However, in the 100-yard crawl and 440-yard crawl swim the contribution of the factors change with a greater contribution from the factors associated with endurance,

i.e., the circulatory-respiratory, buoyancy, horizontal floating capacity, and flexibility factors.

Factors in a 100-yd. sprint were found to be: arm stroke efficiency, 46.2 per cent; coordination efficiency, 21.5 per cent; sitting diastolic pressure, 11.5 per cent; gliding efficiency, 8.5 per cent; breath holding on flarimeter after exercise, 7.8 per cent; leg kicking efficiency, 2.9 per cent; Rogers' Strength Index, 1.3 per cent.

Karpovich's important studies on water resistance, timing within phases of the stroke, propelling force, work, and energy are recognized as being factors in swimming.[32]

According to this review, endurance studies by Cureton, Larson, and McCurdy indicated in 440-yard swimming that the swimming time could be predicted to a fairly high degree by a combination of standing diastolic pressure, breath holding on the flarimeter after two minutes of exercise, pulse rate after exercise, and the difference between lying and standing diastolic. Adding stroke mechanics raised the prediction value. The most important of ten efficiency factors studied in the 440-yard swim were found to be mechanics of stroke, thigh flexion strength, pulse immediately after exercise, ability to glide well for distance, trunk flexibility in forward bending of the hips, and blood pressure.

Educability in Motor Fitness.—Some skills are very much more *educable* than others; jumping, for instance, is markedly affected by the structural proportions in the levers. A person with a *crural index below* 85 will not make a top-flight jumper regardless of the time spent on methods used in training. Likewise, a swimmer with an extremely poor horizontal floating capacity will never achieve a remarkable record in distance swimming. In general, events which are dominated by body build relations of this type are less educable than those which depend upon modifiable factors.

Learning curves which show the amount of improvement associated with stated amounts of practice and time, or with various methods of learning, are important. Studies of this type have been reported by Johnson,[30] F. A. Johnson,[29] McCloy,[40] and Cureton.[19, 20]

GENERAL OR CROSS-SECTION TESTS OF MOTOR ABILITY

One of the early leaders of physical education in this country, Dudley Sargent, represents in his work the modern attempt to measure scientifically through various means the capacity of the physical man, first by anthropometrical measurements with the tape and calipers, then applied strength on the dynamometer, and finally the Sargent Jump [55] to determine a man's measure of general power. The Sargent Jump has been found to be a valuable general motor ability test. It does not test all of the elements of general motor ability. If used in connection with other tests, it may be of great usefulness in a program of physical education, according to McCloy.[42]

Kleeberger,[33] using as a guide three types of physical prowess, set up as essential, has developed tests in agility, swimming, and defense for college men. Grading is on the basis of the usual college marks of A, B, C, D, and E. The scales were based on freshmen from the University of California. Besides being related to college men these tests of physical prowess could be used for men of the army and navy.

Army tests of physical efficiency are described by Thomas J. Browne as they were conducted at Camp Gordon in Atlanta, Georgia, in 1918.[6] Minimum standards are set up in the running broad jump, running high jump, vault, wall scaling, sprint, and half mile. Some tests with light combat equipment with rifle were experimented with: namely, running broad jump, running high jump, and vault (rifle in one hand).

Indices of athletic and motor ability (fundamental skills) have been normed for Springfield College men. Norms are given for all-round athletic ability, gymnastic ability, and aquatic ability. These are given in the list of *Available Norms and Scoring Tables.*

SPECIFIC TESTS OF MOTOR ABILITY

Many tests have been developed to measure achievement in *specific* aspects of motor ability. Some of the areas covered are listed as follows: *

	Author	*Date*
Archery	Hyde[28]	1933
Baseball (Playground)	Rodgers and Heath[53]	1931
Basketball	Davis[22]	1932
	Edgren[25]	1932
	Money[46]	1933
	Friermood[26]	1934
Dancing	Annett[3]	1932
	Weckwerth[60]	1934
Gymnastics	Reuter[51]	1919
	Lehman[37]	1927
	McCloy[39]	1934
Soccer	Heath and Rodgers[27]	1932
	Vanderhoof[58]	1932
	Konstantinov[34]	1940
	Lee[36]	1941
	Munro[47]	1941
Swimming and Diving	Cureton[16, 17]	1933
	Parkhurst,[49]	1934
	Cureton[14]	1934
	Cureton[15]	1934
	Cureton[21]	1935
	Karpovich[32]	1935
	Y.M.C.A.[13]	1938
Tennis	Dyer[24]	1935
	Wagner[59]	1935
	Condon[8]	1941
Track and Field	Crapser[12]	1930
	McCloy[40]	1932
	A.A.U. Pentathlon and Decathlon	1940–1
Volleyball	Reynolds[52]	1930

* The references represent only a selection of tests and it is recognized that the listing is not comprehensive.

Items	Technique of Measurement		Subjects' Measurements	Number Cases	Percentile Rating Scale						
	Instrument	Specifications			.1	.6	1.2	2.3	4.0	6.7	
All-Around Athletic Ability:		COZENS' TEST									
1. Baseball throw	Baseball and tape.	Bovard, J. F. and Cozens, F. W. *Tests and and Measurements in Physical Education* Philadelphia, W. B. Saunders Co., 1930, pp. 275–279.	1.5 X	143	101.8	120.2		138.5		156.9	
2. Football punt	Football and tape.	(Total Score)	1.0 X	143	12.2	16.5		20.7		25.0	
3. Long dive	Sawdust or mat and tape.	Superior 421 up Above average 374–420 Average 327–373 Below average 280–326 Inferior 279 down	0.7 X	141	3.75	4.6		5.4		6.2	
4. Standing broad jump	Jumping pit and tape.		1.0 X	144	5.5	6.0		6.3		6.7	
5. Push up	Parallel bars.		0.6 X	143	0.0	.5		1.0		2.0	
6. Dodging	Hurdles and stop watch.		1.0 X	141	31.3	30.6		29.8		29.1	
7. Quarter mile run	Track and stop watch.		1.2 X	142	89.9	86.0		82.1		78.2	
8. Total score			points	141	212.5	235.0		257.6		280.2	
Gymnastic Ability:											
9. Brace test total score	None.	Brace, D. K. *Measuring Motor Ability* New York: A. S. Barnes & Co., 1927. pp. 105–24.	%	263	26.9	34.5		42.1		49.7	
10. McCurdy's balance beam test	Balance beam 2 in. wide and 18 ft. long.	4 steps forward, turn around, squat on heels, stand, 3 steps forward. (10 counts)	counts	115	3.4	4.0		4.6		5.2	
11. Rope climb	1½ in. rope 20 ft. long and stop watch.	Time required for climb or feet climbed if unable to reach top.	sec. ft.	70	2.0 ft.	4.0 ft.		6.0 ft.		10.0 ft.	
12. Burpee test	Stop watch.	Number of counts made in 10 sec., squat (1), legs extended back (2), squat (3), stand (4).	counts	178	11.3	12.8		14.3		15.8	
13. Bar vault	Horizontal bar.	From standing position vault over bar touching (bar) with hands only.	in.	118	40.1	43.8		47.5		50.7	
Aquatic Ability:											
14. 100-yard crawl	Stop watch.	Time for 100 yards using overarm crawl stroke.	sec.	749	156.5	146.4		136.3		126.2	
15. Plunge for distance	Tape.	Plunge from 18-inch high platform at end of pool.	ft.	90	22.3	24.0		25.7		27.4	
16. 40-yard back stroke	Stop watch.	Time for 40 yards using back stroke	sec.	839	63.0	59.0		55.0		51.0	
17. 40-yard breast stroke	Stop watch.	Time for 40 yards using the regulation breast stroke.	sec.	823	59.1	55.4		51.8		48.1	
18. Diving	1 Meter diving board.	Number of dives completed with minimum grade of 5.	no.	378	0.0	1.0		2.0		3.0	
19. Time of treading water	Stop watch.	Using legs alone. Keep hands and head out of water.	min. sec.	58	0.0	8″		15″		27″	
20. 60-foot cross chest carry	Stop watch.	Time required for 60-foot cross chest carry with subject.	sec.	78	58.5	54.3		50.1		45.9	
					—3 σ			—2½ σ		—2 σ	—1½ σ
					20					30	

PHYSICAL NORMS FOR SPRINGFIELD COLLEGE MEN

Indices of Athletic and Motor Ability (Fundamental Skills)

Percentile Rating Scale																Percentile Rating Scale
.1		.6	1.2	2.3	4.0	6.7	10.6	15.9	22.7	30.9	40.1	50	59.9	69.2		
101.8		120.2		138.5		156.9		175.2		193.6		211.9		230.3		
12.2		16.5		20.7		25.0		29.2		33.5		37.7		41.9		
3.75		4.6		5.4		6.2		6.75		7.58		8.42		9.2		
5.5		6.0		6.3		6.7		7.0		7.4		7.7		8.1		
0.0		.5		1.0		2.0		4.2		6.4		8.6		10.8		
31.3		30.6		29.8		29.1		28.3		27.6		26.8		26.1		
89.9		86.0		82.1		78.2		74.3		70.4		66.5		62.6		
212.5		235.0		257.6		280.2		302.8		325.3		347.9		370.5		
26.9		34.5		42.1		49.7		57.3		64.9		72.5		80.1		
3.4		4.0		4.6		5.2		5.8		6.4		7.0		7.6		
2.0 ft.		4.0 ft.		6.0 ft.		10.0 ft.		14.0 ft.		16.0 ft.		25.0 sec.		20.0		
11.3		12.8		14.3		15.8		17.3		18.8		20.3		21.8		
40.1		43.8		47.5		50.7		54.9		58.6		62.3		66.0		
156.5		146.4		136.3		126.2		116.1		106.0		95.9		85.8		
22.3		24.0		25.7		27.4		29.1		30.8		32.5		34.2		
63.0		59.0		55.0		51.0		47.0		43.0		39.0		35.0		
59.1		55.4		51.8		48.1		44.5		40.8		37.2		33.6		
0.0		1.0		2.0		3.0		4.0		5.0		6.0		7.0		
0.0		8″		15″		27″		30″		1′ 57″		3′ 24″		4′ 5		
58.5		54.3		50.1		45.9		41.7		37.5		33.3		29.1		
σ			$-2\frac{1}{2}\sigma$		-2σ		$-1\frac{1}{2}\sigma$		-1σ		$-\frac{1}{2}\sigma$		0		$+\frac{1}{2}\sigma$	
					30				40				50			

Percentile Rating Scale											PER-CEN-TILES	COMMENTS
69.2	77.3	84.1	89.4	93.3	96.0	97.7	98.8	99.4	99.9			
230.3		248.6		267.0		285.3		303.7	322.0			
41.9		46.2		50.5		54.7		59.0	63.2			
9.2		9.75		10.6		11.4		12.6	12.75			
8.1		8.4		8.85		9.1		9.5	9.85			
10.8		13.0		15.2		17.4		19.6	21.8			
26.1		25.3		24.6		23.8		23.1	22.3			
62.6		58.7		56.6		54.4		52.2	50.0			
370.5		393.1		415.6		438.2		460.8	483.4			
80.1		87.7		90.7		93.8		96.9	100.0			—Average Percentile
7.6		8.2		8.7		9.1		9.6	10.0			
20.0 sec.		14.0 sec.		12.0 sec.		10.0 sec.		8.0 sec.	6.0			
21.8		23.3		24.8		26.3		27.8	29.3			
66.0		69.7		71.8		73.9		76.0	78.0			
85.8		75.7		70.0		64.3		58.6	53.0			—Average Percentile
34.2		35.9		37.6		39.3		41.0	42.7			
35.0		31.0		28.5		26.0		23.5	21.0			
33.6		30.0		28.3		26.2		24.1	22.0			
7.0		8.0		10.0		12.0		14.0	16.0			
4′ 51″		6′ 18″		7′ 45″		9′ 12″		10′ 39″	12′ 6″			
29.1		24.9		23.1		21.4		19.7	18.0			

σ +1 σ +1½ σ +2 σ +2½ σ +3 σ

60 70 80

.....Average Percentile

.....Average Percentile of All

SOME AVAILABLE NORMS AND SCORING TABLES

A number of norms and scoring tables for young men exist. Some of these include:

General or All-Round Performance
Cozens,[10] Crapser,[12] Trieb and Neilson [57] Springfield College Norms (see Chart).

Power Capacity and Strength
Rogers,[54] Cozens,[11] MacCurdy,[38] Larson [35]

Track and Field (Including Pentathlon and Decathlon Tests)
McCloy,[40] A.A.U. Pentathlon and Decathlon [2, 50]

Aquatics
Cureton,[19] Y.M.C.A.[13]

Soccer
Konstantinov,[34] Munro,[47] Lee [36]

Tennis
Condon [8]

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CHAPTER VIII

Fatigue and Endurance

PETER V. KARPOVICH

EVERYONE is familiar with the sensation of fatigue, yet an accurate description of its symptoms or a definition of the condition is difficult to conceive. Actually the phenomena observed in the state of fatigue may be subjective or objective.

The subjective sensations have been described by Viteles[7] as "a *feeling of fatigue* or tiredness"; this can hardly be called an adequate description, yet it is difficult to offer any better brief definition. Conceivably, the "unwillingness to work" might be added to Viteles' description, but without much improvement to it. The "unwillingness to work" may not be directly related to fatigue, even as a "feeling of fatigue" may not necessarily mean actual fatigue: such pseudo-fatigue will disappear if the subject persists in work, whereas genuine fatigue will not, of course, disappear with further work.

Objective symptoms are characterized by a decreased capacity for work, by a lower efficiency and by certain changes in the functions of the organs. These changes occur, however, only in cases of considerable degree of fatigue, and are not always evident in the fatigue of industrial occupations; there may be no decline in production toward the end of the day, although a certain degree of fatigue does develop during that time.

Subjective sensations in the early stages of moderate fatigue may not be accompanied by any discoverable objective findings, which makes it impossible to designate with precision the onset of fatigue or the degree of its magnitude.

Fatigue is often divided into two types: mental and muscular. By the first type is understood a state of fatigue which results from mental work. The muscular fatigue is that caused by muscular work. Unfortunately the expressions "muscular fatigue" or "physical fatigue" are often interpreted as the muscles themselves being tired. This conception is so common that if one tells a tired athlete who has just completed a cross-country run that his leg muscles are really not tired, it would be taken as a poor joke.

However, numerous experiments prove this without any doubt. One may take a frog muscle and by stimulating it through one nerve bring it to a state of apparent exhaustion. Then, if stimulated again through another nerve branch, hitherto not used, the tired muscle will again perform as if it were fresh. It has also been established that the nerve trunks under normal conditions are non-fatigable. Therefore, the

seat of fatigue should be looked for in the following structures: motor cells of the brain, nerve synapses, the motor nerve endings and the sensory end organs. Experimental evidence leads to the conclusion that the local sensations of fatigue originate in the sense end organs. As to the other nerve structures, just how much they are involved is unknown at the present time.

CAUSES OF FATIGUE

Simonson [6] and Dill et al. [1] subdivide the possible causes into four groups: (1) accumulation of fatigue products; (2) depletion of fuel for muscular contractions; (3) inadequacy of the oxygen supply; (4) alteration of the physico-chemical state. Schneider [4] lists only three causes; namely, the first, second, and fourth of the preceding classification. It is obvious that accumulation of the fatigue products and even depletion of the fuel, broadly speaking, may be considered as a part of the alteration of the physico-chemical state, but they have been singled out because of their greater conspicuousness.

All these changes may be observed in cases of a considerable degree of fatigue such as result after strenuous muscular work. In most cases of everyday fatigue, such as industrial fatigue, none of these changes may be discovered. In these cases one may use a very convenient explanation that the changes are so slight that they cannot be discovered by present physiological methods. This is probably true, because by employing more delicate psychological tests the degree of the change in human behavior may be measured when physiological tests fail. Unfortunately, psychological tests may be affected by such a variety of factors that the data obtained may not be reliable.

PROOFS OF LOCAL FATIGUE

Zuravlev and Feldman [8] exercised the muscles until performance decreased due to fatigue. After this, a one minute rest was given, during which time the blood circulation had been stopped by means of a pneumatic tourniquet. One minute later circulation was restored and exercise was resumed. Recuperation was practically absent. This can be interpreted as a proof that the cause of fatigue was peripheral, and due to an absence of the circulation the products of fatigue could not be removed. On the other hand, it may be interpreted that the anemic, tired tissues during that one minute of rest have been sending depressing stimuli to the brain and so no central recovery from the fatigue could take place. A common observation that a local massage is an aid in recovery from fatigue may also be interpreted as favorably affecting the central nervous system by removing local accumulation of fatigue products. It would be of interest to perform a similar series of experiments on a person suffering from loss of conduction of sensory impulses, as, for instance, in tabes dorsalis.

LOCAL AND GENERAL FATIGUE

Fatigue may also be subdivided into two types, depending on the parts of the body affected, whether only a few parts of the body "feel tired," or whether the condition seems to affect the functioning of every muscle in the body. If one accepts physico-chemical changes as the cause of the fatigue, then the difference would depend on the amount of these changes.

DEGREE OF FATIGUE

There are many transitional degrees of fatigue. These may inaccurately be described as light, medium, and severe. After this follows an overfatigue, or exhaustion.

STALENESS

When work is continued for many days or weeks without a sufficient amount of rest, a state of chronic fatigue may develop. This fatigue usually disappears after a prolonged period of rest.

There are, however, cases when with an ordinary amount of work and an apparently sufficient amount of rest, persons develop symptoms of chronic fatigue. This has been observed among soldiers, industrial workers, and athletes. Analysis of the situation discloses that in every case there was an outstanding factor of mental unrest. It was not the muscular work, but the mental anxiety, that brought about this condition, which is commonly referred to as *staleness*. An actual or imaginary unfair treatment by an officer, foreman, professor, or coach may cause a state of frustration, although the intimate nature of the developing of staleness is not well understood.

Yet there is ample experimental evidence supporting this. Pavlov[3] has been able to develop a state of "neurasthenia" in dogs by causing a "false alarm" too often. Selye[5] found that if the animals are constantly annoyed and irritated, even ulcers of the intestinal canal may develop.

The fashionable "nervous breakdown" which is attributed to overwork is not caused by even an enormous amount of quiet work. Usually one can recognize an intensive emotional factor involved.

A wise administrator, or a coach, recognizes the importance of emotional conditions, and by stimulating them or quieting them he obtains a maximum amount of work from his men.

SYMPTOMS OF STALENESS

Three types of staleness are recognized[4]: (1) the cardio-vascular staleness which is characterized by a fast pulse, distress on exertion, and cold extremities; (2) the nervous staleness with a loss in coordination, tremor of hands and eyelids, and increase in reflexes; (3) the muscular staleness with loss in muscular strength.

It is difficult to observe among the college athletes a clearcut picture of any one type of staleness; the condition is ordinarily a combination of these types. The athletic performance usually becomes erratic and lowered. Men are irritable, suffer from insomnia. Scholastic work also becomes worse, and some students exhibit symptoms of hypochondria.

Regardless of the type, the treatment is the same. The men should continue their participation in exercise, but the intensity should be lessened,[2] and the periods of rest should be increased. The coach should tactfully find the cause of the staleness, and skillfully eliminate it. The man should be encouraged and helped to regain self-confidence.

ENDURANCE

Endurance may be thought of in terms of *how long* a certain exercise can be continued. If the exercise, as is often the case, involves a repetition of a certain movement, endurance may be expressed in terms of how *many times* one movement has been repeated.

It is obvious that the state of fatigue determines the limit of endurance; therefore all the factors which delay the onset of fatigue also increase the endurance. Hence, in discussing the reasons for a greater endurance, the same items may be considered as were used in the discussion of the causes of fatigue.

Endurance depends upon the ability to counteract the accumulation of the fatigue products; an ample store of fuel; an adequate oxygen supply; and the stability of the physico-chemical state of the organs and tissues. This is the obvious reason why a capacity for endurance reflects the degree of physical fitness.

TESTS FOR ENDURANCE

All tests may be divided into the direct and indirect. *Direct tests* are those used when endurance is tested by the activity in question. To this class belong all actual athletic trials, ergometric tests, chinning, dipping, etc. *Indirect tests* consist of testing certain muscle groups, or functions of various organs and systems, and attempting to interpret the result as an index of endurance in some muscular activities. This may involve a great variety of tests, such as testing the maximal oxygen consumption, chemical composition of the blood, and cardio-vascular reaction to some standard exercise. Chinning, dipping, and other similar tests may be used as indirect tests, if the results obtained are used to predict man's ability on the track, in the swimming tank, or on the field.

The direct tests of endurance are the best, but there are occasions when they are either impossible or impractical, or even dangerous if the subject is suffering from some serious ailment.

INDIRECT TESTS OF ENDURANCE

Blood:	a greater amount of the red blood corpuscles
	a larger amount of buffers
	a larger amount of hemoglobin
Heart:	a slower basal pulse rate
	a larger stroke volume during exertion
	a better reaction to some cardio-vascular tests
Lungs:	better lung tissue permeability for the oxygen
	a relatively larger lung capacity
Oxygen:	a greater amount of oxygen which could be assimilated during a strenuous activity

None of these factors alone is characteristic for the endurance. Oxygen consumption test is probably the best, because it involves all of the other factors mentioned. Surprisingly accurate predictions of performance may be made using the oxygen consumption test. Unfortunately the tests require a great deal of time and technical skill; therefore they are not practical. Their value is pedagogical, since it shows a close relationship between the training conditions as reflected in the amount of oxygen needed and muscular performance.

Physical educators are constantly searching for short cuts, some magic formula, ***the one*** test which could determine physical and health condition. The brief history of tests and measurements is full of these attempts, some of them already curious relics of the past, bearing witness to a constant effort to apply physiological knowledge to practical needs.

DEVELOPMENT OF ENDURANCE

When Weichardt produced his kenotoxin, or fatigue poison, and tried to increase endurance of animals by injection of the antikenotoxin, he failed completely. Yet, indirectly his experiments were responsible for broadening the understanding of fatigue. He gave an impetus to the idea that endurance is a state analogous to a state of partial immunity. Immunity may be produced actively by introducing a certain amount of antigen, thus stimulating the formation of antibodies which protect the organism from an actual infection. Training may develop endurance. During bodily exercises a certain amount of fatigue products is developed and the organism is trained to take care of it. By gradually increasing intensity of exercises the active immunity to fatigue greatly increases. This involves mainly a changed activity rate of the organs and systems, rather than a definite composition pattern of the tissues, including blood.

In training it is natural to use the activities in which one is going to compete or activities closely related, or auxiliary activities. For example, if one is preparing for boxing he should practice actual boxing, or punching the bag, rather than weight-pulling. He also should use running as an auxiliary exercise, because it would increase his capacity

for oxygen transport and its utilization. Endurance develops gradually and the time necessary for reaching a maximum depends on several factors: type of exercise, its relative difficulty, frequency and duration of practice.

In this connection it would be of interest to mention here training curves obtained recently by Karpovich and Pestrecov on inmates of the County Jail and on college students. The subjects worked on stationary bicycles five days a week, working as long as they could. The jail inmates worked at the rate of .159 to .216 H.P., and 70 pedal revolutions per minute. The students worked at .5 H.P. and 117 pedal revolutions per minute.

The character of training curves was not the same for the different men. One of the reasons was a relative strength of the men. The stronger men improved more than the weaker ones. It is interesting to report that when the experiments in the jail began, some of the men were in such poor physical condition that four weeks were spent on general body building exercises. Even after this the men could hardly ride the bicycle more than 5 minutes. By the end of the experiment some men rode uninterruptedly for more than 6 hours. One subject increased his endurance over 4,000 per cent.

Students exercised 10 weeks; again it was observed that the stronger men usually improved more. By the end of a 10-week experimental period, performances improved from 49 per cent to 334 per cent. After this one man rode the bicycle for 9 more weeks. His performance increased even more, reaching 463 per cent. Bicycle experiments thus showed that maximum performance may not be reached by some men even in 19 weeks. This should be taken into consideration by some school administrators who, on the one hand, may demand a superb performance from the teams and, on the other hand, forbid pre-seasonal training. A strictly seasonal training is an impossibility for the desired results; it means competitions without adequate preparation.

Activities which require peculiar muscular action not met in ordinary daily activities would require more practice than some more natural activities. For this reason swimming would require more practice than running.

It would be of great interest if the coaches compiled and published their training curves for various activities. It would show how physical fitness is affected by the different methods of training, and how different individuals respond to the same type of training.

The jail experiments were also interesting in this respect, that every time the men rode the bicycles they attempted to break their records of the previous day. It may be seen from the performance curve that on many occasions this was impossible. Usually severe exertion was followed by a drop in the performance on the following day, and it sometimes took a couple of days to come back. In spite of such a

strenuous schedule, the better subjects showed no symptoms of staleness. Their health, on the contrary, improved. Yet, no coach would follow this method of training. It seems, however, to be quite safe to reach a maximum exertion not involving emotional displays twice a week in an activity requiring considerable length of time.

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CHAPTER IX

Metabolism and Energy Used in Exercise

PETER V. KARPOVICH

THE effect of a given exercise is related not solely to the nature of the work, but also to the intensity with which energy changes occur. The chemical processes caused by physical activities are in proportion to the *rate* of energy expenditure, and *in toto* these changes are termed metabolism, which is usually ascertained by tests concerned with the determination of oxygen consumed and carbon dioxide expired by the subject. From these the energy expenditure is calculated. *Resting* metabolism represents the amount of energy expended during inactivity, while the term *basal* metabolism is applied to the lowest energy necessary for mere existence. The latter varies with age, sex, height, and weight. In the average athlete it may be equivalent to 200-255 cc. of oxygen per minute, or roughly, about 1 large calorie per hour per kilogram of body weight.

Metabolism tests serve many purposes. In the army they have been used to find out the most economical rate and length of the military step and also the best weight and distribution of the load carried by a soldier. Industry has employed them to ascertain the amount of energy used in various kinds of work. In the field of sports and physical education, runners, bicycle riders, swimmers, gymnasts, and football players have been tested in order to find the absolute expenditure of energy and also the relative difficulty of each type of exercise. Schools of physical education seem to make little use of the accumulated data, yet this material is of evident practical value.

Kennedy [7] measured the amount of energy used in various exercises officially adopted by the British Army. He found that the mean metabolism of all exercises varied from 5 to 6½ times that of the basal metabolism rate. Marching and running are among the "costlier" activities, raising metabolic rate from 7 to 10½ times.

The cost of exercise, in Kennedy's work, was based upon the drill program of the army manual. The drill periods at the beginning demanded less energy than those at the end of the training. Of course, this is true only when the exercises are performed by experienced men. A novice may spend more energy on a new, light exercise than on a more difficult but familiar one, owing to the waste of energy in poor coordination.

Missiuro and Perlberg [9] tested the metabolism during exercise in Swedish gymnastics. They found that the cost of a class in Swedish

gymnastics for a subject 22–23 years of age was 3½ times that of the basal rate.

WEIGHT REDUCTION

A knowledge of the amount of energy used in various exercises would save weight-reduction enthusiasts from making promises that are physiologically impossible of fulfillment. Take the case of a 160-pound woman who is 20 pounds overweight. If she were to exercise each day for fifteen minutes, she probably would expend not more than an extra 60 calories. Since one pound of fat can produce 4222 calories, it would take about four years to lose those 20 pounds. With a 3-mile daily walk it would take about 10 months, since it takes about 45 miles of walking to burn one pound of fat. All this would be possible if the lady in question controlled her appetite; otherwise an extra slice of bread or three lumps of sugar would offset the effect of the 15-minute exercise. A piece of rich cake, or one and a half doughnuts, would restore the energy lost in the 3-mile walk.

PRINCIPLES OF METABOLISM TESTING

The purpose of a metabolism test is to determine the amount of extra oxygen used in working as compared with the amount of oxygen used during the same length of time in a resting state. When the work is light, only two test periods are needed: (1) a test while the subject rests before the exercise, and (2) a test while the subject is exercising. From the amount of oxygen used during exercise subtract the amount of oxygen which he would have used if he had remained resting. The excess oxygen will serve as a measure of energy used in work.

When exercise is sufficiently strenuous, the subject will have to depend on two types of energy: one, the aerobic, with the aid of oxygen inhaled during work; and the other, anaerobic, without the aid of oxygen during work. As a result of the anaerobic process, the subject will be in a state of dyspnea at the end of the work. He will then continue to use an excess of oxygen until recovery takes place. This excess oxygen taken during recovery is called the "oxygen debt." It is obvious, therefore, that in such a case three periods of testing are necessary: to the resting and work periods should be added the third test, which measures oxygen consumed during the process of recovery.

Suppose a subject worked A minutes and recovered during B minutes. The amount of oxygen used for work will be found according to the following equation:

$$\text{Work oxygen} = (\text{oxygen used during work} + \text{oxygen used during recovery}) - \text{resting oxygen in } (A + B) \text{ min.}$$

In some cases there are practical difficulties in collecting expired air during the work. If the duration of work is short, the breath may be held until work is stopped, and the oxygen debt will be the measure

of energy used. When work is prolonged for several hours, and the rate maintained is the same, then it is sufficient to measure the metabolism from the beginning of exercise until a so-called steady state is reached. Then, since during the steady state oxygen consumption becomes uniform, metabolism may be measured at regular intervals.

PROCEDURE IN TESTING METABOLISM

There are several methods of testing metabolism, but the Douglas method is the most usable. The subject breathes through a system of two valves allowing him to inhale ordinary air, while the expired air is automatically collected into large rubber bags. Then the samples of the expired air are taken from the bags and analyzed for per cent of oxygen and carbon dioxide content by means of a Haldane apparatus. The volume of air in the bags is measured with the aid of a gas meter, and the temperature and barometric pressure are noted, because the volume of any gas is directly proportionate to temperature and inversely to barometric pressure. Corrections for the temperature and pressure are introduced, and finally the volume is calculated as if the pressure were 760 mm. and the temperature were 0° C. Multiplying the total expired air by the percentage of oxygen and carbon dioxide will give the total amount of each of these gases in the expired air.

Knowing the amounts of oxygen consumed and carbon dioxide given off during exercise, it is possible to tell the proportion at which the carbohydrate and fat are being oxidized. (The allowance for protein oxidation is not important in most of the experiments.)

For example, suppose that as a result of a certain exercise, the amount of oxygen used was 10 liters, and the amount of carbon dioxide given off was 9 liters. It has been established that 1 gram of carbohydrate in oxidation takes up 0.828 liters of oxygen and gives off 0.828 liters of carbon dioxide; that 1 gram of fat in oxidation takes up 1.989 liters of oxygen and gives off 1.419 liters of carbon dioxide.

Assuming that during exercise X grams of carbohydrate and Y grams of fat were used, it is possible to write two equations, (1) and (2) which can be easily solved:

$$(1) \quad 10 = 0.828\,X + 1.989\,Y$$
$$(2) \quad -9 = 0.828\,X + 1.419\,Y$$

$$1 = 0.570\,Y$$
$$Y = 1.75 \text{ grams of fat.}$$

Substituting 1.75 for Y in either of the two equations, it will be found that $X = 9.08$ grams of carbohydrate. Since the caloric value of 1 gram of carbohydrate is 4.2, and that of 1 gram of fat is 9.3, the total amount of energy used up is equal to 49.3 calories. This means that for every liter of oxygen used, 4.93 calories were produced. When carbohydrates alone are oxidized, as many as 5.047 calories are de-

veloped, whereas, in oxidation of fats only 4.686 calories are produced. This shows that oxidation of carbohydrates is more economical, less oxygen is needed, and the respiration and circulation are taxed less.

CARBOHYDRATES, FATS, AND MUSCULAR WORK

Krohg and Lindhardt [8] found that, in general, mechanical work is about one-tenth more efficient with carbohydrates than with fats. With an increase in intensity of work, this difference may greatly diminish man's capacity for work.

Christensen (Dill,[1]) clearly demonstrated the advantage of a carbohydrate diet over one rich in fat. His subjects were able to maintain an intensive rate of work for four hours with a diet rich in carbohydrates; whereas, on fats they were exhausted in ninety minutes. To understand why such a difference in performance was possible, where there is only one tenth difference in efficiency, one should imagine a long distance runner trying to speed up his customary pace by even less than 10 per cent. He may not even finish the race on account of exhaustion.

The fact that fats are less efficient for muscular work than carbohydrates has been often interpreted as an indication that fat should be eliminated from the diet. An extreme case is that of one high school basketball coach who prohibited the use of whole milk on account of its *cream content*. Careful experiments have shown that even in men who live on a diet poor in fats, fats are used as a fuel during muscular work, and this cannot be prevented.

Dividing the amount of carbon dioxide given off by the amount of oxygen used up, one obtains a ratio CO_2/O_2 which is called *respiratory quotient*. Special tables have been prepared which, if the respiratory quotient is known, show at a glance the proportion in which fats and carbohydrates are used, and the caloric equivalent of each liter of oxygen.

WORK METABOLISM

According to Dill [1] work may be considered as moderate when metabolism rate is less than three times basal metabolism rate. When metabolism is increased eight times, it is hard work but can be maintained for eight hours. The limit of human capacity for increasing metabolism is about ten times for ordinary people and as high as twenty times for athletes. Thus, some athletes whose basal metabolism required only 250 cc. of oxygen per minute were able to assimilate 5000 cc. during severe work.*

There is a great deal of uncertainty regarding the changes in basal metabolism during training. Steinhaus [12] gives a brief and concise review of this question. Increase, decrease, and no change have been

* In case of anaerobic work, when energy used depends on oxygen debt, the metabolic rate may be increased one hundred or more times that of basal rate.

reported. The five-year-long observations made by Steinhaus on dogs whose diet and training conditions were well controlled indicated a slight decrease in the basal metabolism rate.

Morehouse [10] carried out investigations on twenty athletes in and out of training, in which he took care to meet the criticism leveled against other similar researchers. The men were given an ample chance to get used to the discomfort connected with testing, and they never were tested on the day following strenuous exercises. The diet was maintained as uniform as possible. His conclusions were that metabolism was not materially altered by training. Although basal metabolism was 2 per cent higher in training, the difference lies within the normal range of fluctuation of metabolism. He also noticed that metabolism was lowest in December and highest at the beginning of March. This seasonal variation coincides with the observations made by Gustafson and Benedict.[3] Hellebrandt et al.,[4] however, observed no seasonal trend in girls.

Physiologic analysis of athletes' training clearly indicates that as far as metabolism is concerned it involves two important and inseparable features: (1) to make movements more economical; and (2) to increase man's capacity for maximum metabolism. The first is achieved through an improvement of "form," by eliminating the unnecessary movements and the improvement of the essential ones. The second coincides with the improvement of the circulatory system—heart and composition of the blood. The heart should be able to pump more blood, and the blood should be capable of carrying more oxygen.

All necessary adjustments take place gradually and automatically as a result of training. As already mentioned, diet also may affect the efficiency of metabolism.

CONSTANCY OF METABOLISM

Numerous experiments have shown that during the initial phase of training, the efficiency of performance noticeably improves. By per cent efficiency is meant the ratio:

$$\frac{\text{mechanical work} \times 100}{\text{energy used}}$$

But later, improvement becomes negligible, so that the efficiency may be considered constant for the same individual with the same duration and rate of work.

Using this as a basis, Sargent [11] has been able to predict the time of running various distances up to 3,450 yards, actually testing the subject in running only 100 yards at various speeds. Predictions were amazingly close, so that Hill [5] referred to them as "too good to be true." Greene,[2] under the writer's direction, verified Sargent's work and showed that the same method could be applied to the crawl stroke.

Karpovich and Le Maistre [6] applied this to the breast stroke with the same success.

Although these tests have little practical value, because they involve a great deal of time and require special equipment and skills, yet they offer such an intimate insight into the relationship between the metabolic changes and the athletic performance that it seems worth while to discuss briefly the latest experiments.

PREDICTION OF SWIMMING TIME IN BREAST STROKE BASED ON METABOLISM TESTS

A varsity swimmer was asked to swim 120 feet, holding his breath. His resting metabolism before and the oxygen debt after a swim were found. Each testing day he swam once at a different rate of speed, trying to keep the speed uniform throughout the entire distance. The Douglas method was used. In this manner of testing, the amount of oxygen needed for various rates of speeds was determined. This is presented in Table I and also graphic form in Figure I. From Table I it may be seen that the maximum oxygen debt of this particular swimmer was rather low, only 10.32 liters.

The next step was to find out the maximum intake of oxygen pos-

TABLE I

OXYGEN REQUIREMENT FOR CERTAIN SPEEDS IN BREAST STROKE SWIMMING

Swimming Distance in Feet	Time Sec.	Speed Ft./Sec.	Total O_2 Used Liters	O_2 Required per 1 min. Liters
120	43.5	2.76	2.246	3.1
120	37.0	3.24	4.281	6.95
180	51.0	3.53	8.044	9.46
180	45.0	4.00	10.320	13.78

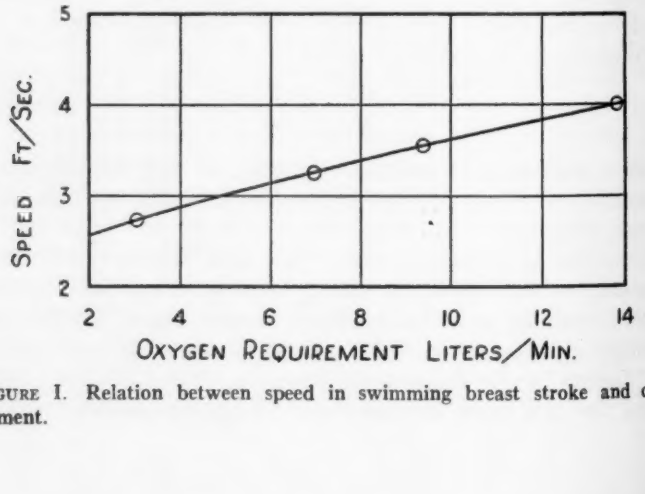

FIGURE I. Relation between speed in swimming breast stroke and oxygen requirement.

sible during swimming. For this purpose the man was tested in a stationary swim (tied by a rope to a post). It was found that by the end of the first minute oxygen assimilation was 3.747 liters; second minute 3.806; and third 3.877.

Knowing the oxygen debt and the maximum oxygen consumption per minute, the amount of oxygen "available" for swimming for various lengths of time was calculated. It was assumed that, in each case, the maximum oxygen debt was reached. Therefore, the oxygen available was found in this way:

$$O_2 \text{ for } (n) \text{ minutes} = \text{maximum } O_2\ (n) + (\text{oxygen debt.})$$

Dividing by n, the oxygen used in one minute is found. The results of these calculations are presented in Table II.

TABLE II

THE DISTANCE COVERED IN A GIVEN TIME WHEN CORRESPONDING MAXIMUM SPEEDS ARE USED

Time in min., T	1	2	3	4	5	8
1. Max. O_2 debt, D. Liters	10.32	10.32	10.32	10.32	10.32	10.32
2. O_2 Intake, I*, Liters	3.52	7.15	10.94	14.58	18.23	29.17
3. Total O_2 "available" (D+I)	13.84	17.47	21.26	24.90	28.55	39.49
4. O_2 available per 1 min. (D+I): T	13.84	8.73	7.08	6.22	5.71	4.94
5. Corresponding speed, S ft./sec. (found in Fig. I)	4.02	3.52	3.30	3.20	3.13	3.03
6. Distance covered, in ft. (S×T)	241	422	594	768	939	1454

* Figures in this row are net, the resting consumption of oxygen having been subtracted.

The distances (Line 6, Table II) were plotted against the corresponding times (found at the top of each column in Table II) and thus was obtained a "prediction curve" shown in Figure II which indicates the swimming time for any distance up to 1800 feet. For instance, a distance of 800 feet would require about 250 seconds, and 1100 feet will be covered in 350 seconds. On the same graph is indicated by small circles the actual times for various distances. As one may see, these circles are practically on the prediction curve. In Table III are presented the actual and predicted times for some distances. The closeness is "almost too good." Of course this prediction curve is good only for the man who was used as a subject for its construction.

METABOLIC PROCESSES DETERMINING AND LIMITING WORK CAPACITY

Sometimes one wonders why a certain man cannot run or swim more rapidly. Table II gives the answer. Line five in that Table indicates that for a speed of 4 feet per second, the subject requires 13.84

liters of oxygen per minute, and this amount is at his disposal only when he swims just one minute. When he swims two minutes, his oxygen available per minute becomes only 8.75 liters, and the speed has to drop accordingly, being in this case 3.52 feet per second.

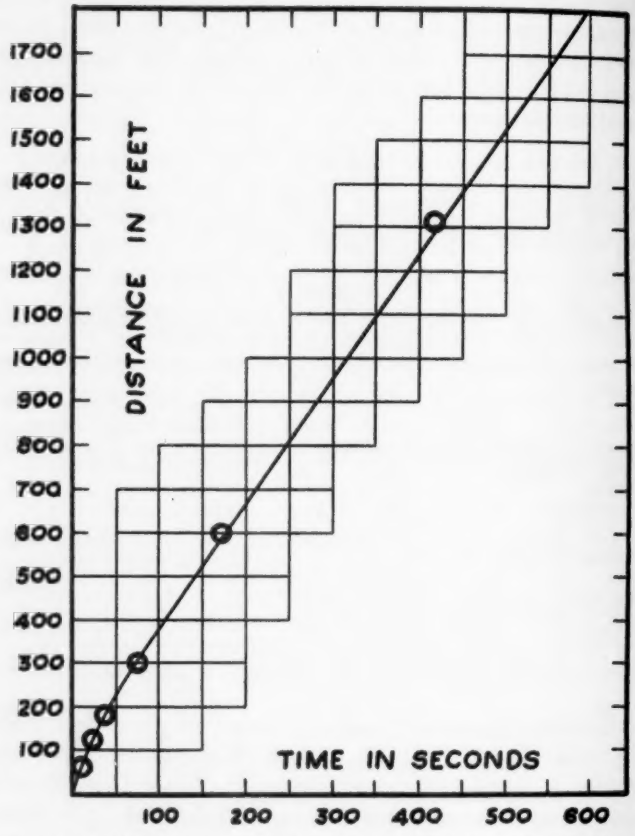

FIGURE II. Prediction curve, showing the predicted time of swimming various distances. Circles indicate the actual times for 60, 120, 180, 300, 600, and 1320 feet.

TABLE III

COMPARISON OF THE ACTUAL AND PREDICTED TIME FOR BREAST STROKE SWIMMING

Distance in Feet	Actual Time in Seconds	Predicted Time in Seconds
60	12.7	12.7
120	26.0	27.0
180	44.5	46.0
300	76.7	72.5
600	173.0	180.0
1320	420.0	430.0

It is also a simple matter to demonstrate why a sprinter depends more on his greater oxygen debt, and a long distance man has to rely on his maximum oxygen intake during the exercise.

Suppose there are two swimmers, *A* and *B*, identical in all respects except for their oxygen intake and oxygen debt.

Subject	Oxygen Intake Liters/min.	Oxygen Debt Liters
A	4.5	10
B	3	16

During the first minute *A* will have 14.5 liters of oxygen and *B* 19 liters, therefore *B* will be able to move faster than *A*. Swimming a distance requiring 10 minutes, *A* will have 55 liters of oxygen; whereas, *B* will have only 46 liters, and therefore *B* will be slower.

There are many unsolved problems regarding the bodily changes taking place during training. The intimate nature of metabolic changes is also obscure. However, it offers a gross, and the most inclusive, index of physical fitness, because it reflects the function of most of the bodily organs and systems. Inefficient heart, lungs, kidneys, or blood would result in a lowered metabolic capacity.

It is the writer's sincere hope that sometime the laboratory process involved in these tests may be simplified and that it might be possible to use some specially devised metabolism test as a practical index of fitness.

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CHAPTER X

Ergogenic Aids in Work and Sports

PETER V. KARPOVICH

IN FACING a situation where a rapid increase in physical fitness is of great importance, several questions immediately present themselves: Are there any special foodstuffs, drugs, or any other means which will increase work capacity? What are they? Are they dangerous?

Newspapers, and even scientific periodicals, from time to time carry articles describing the remarkable effect of various "aids," which are able to increase muscular strength and the speed of movements, and delay the onset of fatigue, thus improving endurance.

In most cases, a wave of enthusiasm affects the would-be investigators of these "aids," and the result is poorly controlled experiments which unfortunately support the original work, when that work in itself may be questionable. Critical and contradictory articles soon appear, but as usual, the negative findings are slower in affecting the practical field, and the impetus gained by the "positive" observations may prevail for a long time, especially if supported by commercial interests.

On the surface it may seem simple to determine the effect of some substance upon muscular performance: merely to test the subjects before and after the administration of the substance in question. This may be sufficient in some cases in which the effect of a big dose of a powerful drug is tested, but in most cases the doses are relatively small, and their effects are not obvious. The common error in many investigations is the absence or inadequacy of control in the experiments. The practical men—athletes and their coaches—are especially guilty whenever they ascribe success in games to the use of some substance. The weakness of such assumptions is evident. There are so many factors involved in sports which require skill and team coordination, as well as changes in team personnel, that it is practically impossible to discern the effect of any substance in question upon the team performance. Even in experiments with table salt, which drastically reduced the incidence of cramps among football players, it is possible to make but one deduction: it helped only those who would have lost by their sweat more salt than was taken with their regular diet. As to the other men who either consumed enough salt with their food or lost little in sweat, nothing can be said.

In the case of measurable events such as swimming or track and

field sports, it still is not easy to discover the effect of some supposed aids upon performance. One should make allowance for the influence of training, of excitement, and of unpredictable and inexplicable changes in the athlete which make him excel one day and fail another. Results obtained during contests should be compared with experiments made during time-trials. Sham tests in which, instead of the "real stuff," inert substitutes are given should be employed, and the psychological factors should be controlled as much as possible.

In this article most of the pertinent literature related to various aids in work and sports will be reviewed and will be supplemented by recent investigations made in the author's laboratory.

Attention may be called here to the fine reviews of literature on this subject by Baur[7] and Bøje[10,11] which have been helpful in the preparation of this article. Baur speaks of all the possible aids to muscular performance as "drugs." Bøje calls them "dopes." It seems improper to refer to table salt, vitamins, and ultraviolet rays as either drugs or dopes. Although the word "doping" is frequently used in connection with administration of various substances to athletes, and may eventually become a proper term, yet at present its use is objectionable since it connotes an administration of drugs akin to opium. In order to avoid this unfortunate association, it may be advisable to refer to these aids as ergogenic aids, or work-producing aids. As it will be seen many of these aids have either a doubtful effect or have no effect at all upon muscular work. Therefore, the terms "ergogenic aid" or simply "aid" should be taken advisedly.

Question has often been raised concerning the ethics of the use of so-called ergogenic aids. It may be stated here that the use of *a substance or device which improves the physical performance of a man without being injurious to his health, can hardly be called unethical.* As to unethically taking advantage of other contestants who do not use these aids, this should be regarded in the same light as the use of a special diet, massage, special exercises, etc. All these means are available for everyone, and they may be used if so desired. On the other hand, no one would consider the drinking of coffee or tea as unethical, yet the amount of caffeine consumed in these beverages may be quite considerable, and the effects harmful.

Some difficulties of classification arose in organizing the material for discussion. Hartwich[49] divided all the substances in question into three groups: roborantia, tonica, and analeptica. However, this plan must be considered inadequate, since it does not exclude overlapping. In this article all material will be arranged in alphabetical order, according to the dominant chemical component. Also, for convenience, some of the aids will be considered together. Thus, all alkalies will be discussed under one heading, all fruit juices under another, and so on for all large groups.

The following will be discussed: (1) alcohol; (2) alkalies: calcium, bicarbonate of soda, sodium and potassium citrates; (3) ammonium chloride; (4) benzedrine; (5) caffeine: coffee and tea; (6) cocaine; (7) coramine; (8) digitalis; (9) gelatin and glycine; (10) fruit juices; (11) hormones; (12) lecithin; (13) metrazol; (14) oxygen; (15) phosphates; (16) sodium chloride; (17) sugars; (18) ultraviolet rays, (19) vitamins.

The purpose of ergogenic aids is to improve performance, or hasten recovery or both. The nature of their action is not always well known, and may involve one or several of the following possibilities:

1. Direct action upon the muscle fibers;
2. Counteraction of fatigue products;
3. Increase of the fuel needed for muscular contraction;
4. Effect upon the heart and circulatory system, increasing their efficiency and thus facilitating the transport of oxygen, fuel, and wastes;
5. Effect upon the respiratory center; and
6. Delay of the onset of the feeling of fatigue by action on the nervous system.

A search through the literature reveals a great complexity of problems involved in the evaluation of the effects of any type of aids. Data obtained under seemingly identical conditions vary a great deal, and the interpretations are often contradictory. It is true that one cannot measure all possible changes, and many so-called subjective effects have an objective basis which eventually may be discovered and measured. Nevertheless, one is forced to accept with reservation any references to subjective sensations, because their reliability is so often questionable.

ALCOHOL

The well-known stimulating and sedative effects of alcohol have been used since time immemorial to bolster one's courage, to counteract fatigue, to forget worries, and "to warm up."

Alcohol in the form of sherry used to be given to oarsmen before a race, but this custom was gradually discontinued after vigorous criticism by Maclaren.[73]

The old experiments by Lombard,[72] Frey,[41] and Joteyko[62] showed that small amounts of alcohol increased muscular endurance. Hellsten,[52] using Johansson's erograph which involves the pulling of weights with both hands, found that small doses of alcohol taken from 5 to 10 minutes before the exercise did increase work for the first 12 to 40 minutes, after which there was a definite drop in performance lasting for two hours. Amounts of alcohol up to 80 cc. of 38 per cent brandy taken half an hour before the test caused a decrease in work output from the beginning of the test; this was substantiated by the work of Toda.[111] On the other hand, Atzler and Meyer[4] found that even 240 cc. alcohol in the form of beer or brandy given immediately or as much as four

hours before the test would increase the work output, providing the men were habitual drinkers. The same amount of alcohol taken the night before caused a marked drop in work capacity.

Simonson[104] administered 4–6 cc. of alcohol with water 20 minutes or less before the test, and he noticed a quicker recovery after work. Herxheimer[56] observed a deleterious effect of alcohol upon speed in swimming or running short distances. The same effect was observed by Hering[54] in 100-, 400-, and 1500-meter races. The amount given was rather large: 100 cc. of 52 per cent alcohol, or the equivalent of about half a tumbler of whiskey. Simonson[104] reported a decrease in oxygen debt after work done following the intake of a small amount of alcohol, whereas Meyer[81] found no change. As to the question whether or not alcohol may be utilized as a source of energy for muscular contraction, opinions differ. Recent investigations by Carpenter et al.[16] and Canzanelli et al.[15] indicate that such utilization does not take place.

A common use of alcohol for warming up seems to draw supporting evidence from the experiments by Menschel and de Rochemont[79] who found that small doses of alcohol would increase the endurance of chilled muscles. This coincides with a feeling of a superficial warmth, caused by a larger amount of blood coming to the skin blood vessels, which were dilated by alcohol. However, the loss of heat is also increased and the danger of greater chilling is enhanced.

There seems to be agreement that large amounts of alcohol are detrimental to muscular performance, but differences of opinion do exist as to the influence of small amounts. Also, the size of the dose is relative, since a "small" dose may be large when used on a total abstainer; and a "large" dose may be relatively small for the habitual drinker. There is no question but that alcohol is definitely detrimental in skill exercises; numerous tests on drivers may be used as evidence.

In conclusion it may be said that alcohol cannot be recommended for the use of athletes. However, additional experiments are necessary to determine whether alcohol is deleterious to athletes who are accustomed to weak wine with their meals, as is customary in countries such as Italy and France.

ALKALIES

During intensive muscular exertion acids accumulate in the blood. To take care of these, more buffer alkalies are needed. It is true that during the training period the alkali reserve of the blood does increase,* yet it is logical to assume that if it were possible to artificially increase the amount of alkalies in the body, this would raise the level of muscular capacity. Such assumption is responsible for alkali feeding of athletes.

Full[48] gave 64 young men five grams of a calcium preparation daily,

* Recent investigations by Robinson (*Am. J. Physiol.*, 132, 757, 1941) cast some doubt on this dogmatic statement.

and noticed a distinct improvement in chinning, jumping, hammer throwing, 25 kilometer marching, 60 meter and 2 kilometer running. However, it was at least five months before any improvement due to calcium became evident. Effect of training was not isolated.

Friedlander[42] gave three to five tablets of Calcipot daily to twenty athletes for five months, and noted a marked improvement in performance. Since in both of these experiments the effect of training was not excluded, their conclusions are open to question.

Dill and his co-workers[33] found that an intake of sodium bicarbonate allows a greater oxygen debt, but could not notice any increase in muscular performance. Dawson[25] cited the case of an athlete who could not complete a long race after taking 10 grams of sodium bicarbonate.

Denning et al.[26, 27] found an increase in endurance after alkali intake. The following prescription was recommended by him:

Sodium citrate	5 grams
Sodium bicarbonate	3.5 grams
Potassium citrate	1.5 grams

This represents a daily dose which should be taken after a meal for two days before a test, and for two days after the test to avoid an acidotic reaction. A longer preliminary period of intake may lower the performance. Denning's experiments were based on treadmill and stationary bicycle tests. In cooperation with Mr. Silvia, swimming coach, Denning's formula is being tried on Springfield College swimmers during time trials and competitions. Administration of these alkalies coincided sometimes with excellent performances. Yet it is premature to make any definite statement at this time.

According to laboratory experiments, it appears thus far that a judicious alkali administration is helpful in raising muscular performance. However, a beneficial effect under competitive conditions has not yet been proven.

AMMONIUM CHLORIDE

When taken into the body, ammonium chloride liberates hydrochloric acid, thus lowering the alkalinity of the blood. For this reason it is used to produce an experimental acidosis. Incidentally, Haldane[48] discovered that this salt makes it easier to adjust oneself to lower oxygen pressure; the beneficial effect is produced by greater lung ventilation which is caused by increased blood acidity. Experiments conducted in a low-pressure chamber showed that working capacity increased upon administration of ammonium chloride (Douglas et al.[34]) and that the subjects could withstand lower pressures (Christensen and Smith[20]). A member of an expedition of Mount Kamet, 8000 m. high, used 0.45 grams of the salt three times a day, and felt that it helped him (Smythe[106]). Bøje[10] thought it might be a boon to aviators and mountain climbers.

All these reports seemed to favor the use of ammonium chloride. However, the subsequent work of Dill and his co-workers,[6] introduced a contradictory note. In their carefully conducted experiments they could not find any beneficial effects of ammonium chloride. Fifteen grams taken in five-gram doses on the day preceding a rapid ascent of 4740 meters did not prevent mountain sickness. The only conclusion which may be drawn at present is that ammonium chloride cannot be considered an aid in mountain climbing or in flying.

BENZEDRINE *

Benzedrine's chemical composition and physiological action are closely related to those of adrenalin. In doses of from 5 to 20 mg. it is capable of abolishing the sense of fatigue, especially when caused by lack of rest and sleep.[82] It should be remembered, however, that it is a powerful and dangerous drug and its excess may lead to insomnia, hypertonia, and circulatory collapse.[111a]

Recent investigations by Dill and his co-workers[29, 46] have shown that injections of 20 mg. of benzedrine may be of some benefit to flyers, because it helps to maintain higher blood pressure during an exposure to a low oxygen tension.

In spite of the rumors that benzedrine has been responsible for an improvement in athletic performance, no scientific evidence has been presented as yet.

CAFFEINE

Caffeine acts upon the blood vessels, heart, and nervous system. It causes general vasoconstriction with simultaneous dilatation of the coronary artery, and increases the contractile power of the heart. It stimulates the central nervous system, accelerating the respiratory rate and shortening the reaction time. In small doses, it acts beneficially upon psychic processes.

Experiments by Mosso[87] showed that caffeine increased muscular performance in finger ergograph tests. Schirlitz[99] found that 0.3 grams caffeine-sodium-salicylate caused a slight increase in work output of subjects riding bicycle ergometers. Schumburg[103a] observed that tea was beneficial in prolonged marching.

Caffeine and cola-nuts (also containing caffeine) were used in a well-controlled experiment by Graf.[45] Subjects riding ordinary or stationary bicycles were given chocolate, either plain or with the addition of caffeine or cola. He found that chocolate with cola had a more noticeable effect than caffeine, raising the work output 20 per cent to 30 per cent.

Toda[111] demonstrated that caffeine produces a temporary improvement in muscular contractility, followed by a longer period of fatigue. Matthias,[77] from observing the effect of coffee on subjects running 800

* An excellent review of literature on benzedrine: Ivy, A. C. and Krasno, L. R., *War Medicine*, 1:15, 1941.

meters, concluded that coffee unnecessarily increases the work of the heart. However, his experiments are rather difficult to interpret. Herxheimer[57] gave 0.25 grams of caffeine-sodium-benzoate to 46 subjects running a 100-meter race, and could observe no effect on performance. Cheney[19] showed that the beneficial effect of caffeine upon the muscles may be independent from its effect upon the central nervous system.

The bulk of evidence shows that caffeine does delay the onset of fatigue and increases work output. Yet the concensus of medical opinion is that the use of caffeine should be prohibited to athletes. It is futile, however, to attempt to prohibit the moderate use of coffee and tea by all, and yet one cup of coffee or tea may contain 1½–3 grains of caffeine, the equivalent of one therapeutic dose. All of which leaves an insolvable dilemma.

COCAINE

Cocaine has a powerful stimulating effect upon the central nervous system, increasing the activity of the cerebrum. It accelerates the respiratory and circulatory rates, has a direct sympathomimetic effect (Burn[14]), and increases muscular tension.

In the form of the coca-leaf, cocaine is used extensively by the South American Indians. This enables them to perform prodigious feats of endurance. They can march for days with little food and rest if they have coca-leaves to chew. It was shown by Mosso[87] that 0.1 gram of cocaine postpones the onset of fatigue. Thiel and Essig[110] found that the endurance of men and women riding bicycle ergometers was increased when they were given 0.1 gram cocaine hydrochloride by mouth. The maximum effect of the drug was noticed 30 minutes after intake. Herbst and Schellenberg,[53] using the same amount of cocaine as above, noted that the speed of recovery after riding stationary bicycles was increased.

Since cocaine is a dangerous, habit-forming drug, its use in athletics cannot be recommended.

CORAMINE

Coramine stimulates the central nervous system. It also affects respiration, increasing the rate and depth at first, and decreasing it later. In cardiac patients it improves the efficiency of the heart, probably through action upon the extrinsic cardiac nerves.[22]

Schonholzer,[101] experimenting on himself, obtained indefinite results. On some occasions he noticed an increased endurance on ski runs, but at other times there was no effect. He also stated that severe cramps which sometimes occur during ski competitions immediately disappeared upon administration of calcio-coramine.

In general, the effect of coramine upon the circulation of normal people is difficult to demonstrate. Sufficient evidence is lacking that this drug is of any value in athletics.

DIGITALIS

Digitalis directly affects the heart muscle, increasing the strength of contractions. In patients with a failing heart, the stroke volume increases, whereas in normal persons it decreases.[21]

Baur[7] states that digitalis has been used by skiers, but he does not report the effect. Bøje[10] cites one case of the development of heart trouble in an athlete due to the use of digitalis.

There seems to be no good reason for the use of digitalis by normal people.

GELATIN AND GLYCINE

Gelatin is an incomplete protein, rich in amino-acetic acid (glycine), which constitutes about 25 per cent of its weight. Glycine is chemically related to creatine, a substance indispensable to muscular contraction. For this reason glycine, and later gelatin, were used in pathological and normal cases in efforts to improve muscular action.

A number of reports of administration of glycine in various muscular diseases stated that it was beneficial, that muscular strength increased and that fatigability decreased. A defatiguing effect of glycine on normal persons was reported by Wilder.[113] This report stimulated further investigations.

Ray et al.,[98] using gelatin of pure glycine, reported an increase of up to 240 per cent work output in men, and no appreciable increase in women. No control experiments were conducted and the effect of training was not excluded. Kaczmarek[63] repeated these experiments, and concluded that "the influence of gelatin was superior to that of mere training." Men improved up to 216 per cent and women up to 501 per cent. No reliable control experiments were carried out, and the effect of training was not fully evaluated. Hellebrandt et al.[51] experimented on women, arranging the gelatin administration in such a manner that its effect would be distinguished from that of training, and although some of the subjects improved as much as 200 per cent, the effect was clearly one of training. They also found that gelatin was of no value in prevention of staleness.

All of these investigators exercised their subjects on bicycle ergometers. Maison,[74] using the finger ergograph, found no effect of gelatin upon the work capacity of the finger (extensor) muscles. Karpovich and Pestrecov[65] carried out a series of experiments on bicycle ergometer riders, on swimmers, heavy-weight lifters, and wall-weight pullers. Diet was controlled in some of the groups. No effect of gelatin upon the working capacity of muscle could be observed. A group of county jail inmates, after twelve weeks of bicycle exercises, improved up to 4420 per cent regardless of gelatin. The maximum time of uninterrupted riding was 6 hours and 12 minutes a day, the rate of work in this case being 0.217 H.P. College students, in experiments similar to those of Ray et al., improved up to 334 per cent; the subject showing the great-

est improvement received no gelatin. The psychological effect of the administration of gelatin was also noticed. When farina was given under the guise of "concentrated gelatin" a noticeable "stimulating" effect resulted.

It may be stated positively that addition of gelatin to a normal diet does not act as a special source of extra power, nor does it increase endurance. In the case of animal experiments, gelatin again failed to show any beneficial effect upon the strength or fatigability of skeletal muscles (Knowlton[67]).

Since gelatin has been used for its glycine content, it indirectly proves the inefficacy of glycine. Observations by Wilder[113] being subjective and non-controlled cannot be considered as a proof to the contrary.

FRUIT JUICES

Dieticians rightfully extoll all kinds of fruit juices for their vitamin and mineral content. Besides all possible benefits derived from drinking fruit juices, they are also supposed to "alkalize the blood," thus increasing capacity for work. Hewitt and Callaway[58] reported an improvement in speed of swimming after drinking either orange or tomato juices. They attributed this to an increase in blood alkalinity.

Numerous tests made by the writer in collaboration with Dr. Pestrecov and Mr. LeMaistre showed that liberal use of various juices, grapefruit, orange, and tomato, had no effect upon the muscular performance of 28 bicycle riders. No significant change in buffer alkalies in blood of 18 men could be observed after administration of these juices to the extent of 3 quarts in 4 hours.

Fruit juices should be considered as an important part of the diet. They may be helpful in building strength and endurance as long as they supply the *needed* amount of minerals and vitamins, but the experimental evidence shows that they are not directly connected with increase in muscular performance. In results obtained by Hewitt and Callaway psychological effect may be suspected.

HORMONES

A profound effect of various hormones upon the vital bodily functions is well known. Thyroxin increases metabolism; adrenalin causes a rise in blood pressure and a greater contractility in the muscles. Lack of cortin is associated with great muscular weakness. All this leads to a hope that hormones might increase muscular strength and endurance in normal people.

The classic experiments of Brown-Sequard on himself with injections of an extract of the testes showed how questionable are the results of non-controlled experiments, no matter how reputable the investigator may be. Brown-Sequard observed a noticeable physical and mental improvement, yet the consensus of opinion is that it was a psychic effect.

Simonson [104] gave 3 tablets of thyreodin daily for 2 to 4 days. All subjects had an increase in basal metabolism averaging 20.1 per cent. Recovery after exercise was accelerated.

Press[95] experimented with sympatol (oxyphenylethanolmethylamine), a substance closely related to adrenalin, on normal and hypotonic persons. They were given 0.15 grams orally before a 2000-meter race; the data showed that sympatol did not increase the work capacity of either normal or hypotonic people.

Campos et al [14a] observed that an injection of adrenalin in dogs before a run had no favorable effect upon performance. However, when injection was made after the animals had reached a stage of exhaustion, it quickened the recovery and enabled them to continue to run. A large dose of adrenalin (.174 mg. per 1 kilogram of body weight) caused great excitement and a decrease in capacity for work.

Dil et al.[32] found that an injection of adrenalin was beneficial because it stepped up the utilization of sugar in work and made the subject feel more energetic. Eagle, Britton, and Kline[36] found that an injection of adrenal cortex extract greatly increased the work capacity in dogs. Indowina[61] found the same was true for rats. Very little improvement could be noticed in men after injections of ½ to 1 cc. of adrenal cortex extract (Missiuro, Dill, and Edwards).[84]

Okamoto[90] and his associates used a follicular preparation called Pelanin on 29 subjects, 19 of whom were athletes. Oral administration of this drug one day before menstruation was found to be capable of retarding menstruation in young women, although this effect was not always apparent in older women.

There is sufficient evidence that administration of hormones may raise the level of physical fitness. Further research in this field will undoubtedly be fruitful.

LECITHIN

Lecithin belongs to the so-called phosphatides, containing fatty and phosphoric acids. It seems to play an important part in oxidation of neutral fats. It also is a fine source of phosphorus, which may be utilized in chemical changes involved in muscular contraction.

Atzler and Lehmann[3] studied the effect of lecithin of soya-bean on 5 persons, giving them 44 grams daily for several days; an increase in the strength and the skill of the hands was reported. Denning[27] also used this type of lecithin and claimed that the effect was favorable. There has not yet been enough work, however, to evaluate clearly the effect of lecithin upon muscular performance.

METRAZOL (CARDIOZOL)

Metrazol (pentamethylenetetrazol) acts primarily upon the central nervous system (Schoen[100]) affecting the vasomotor and respiratory centers. In normal persons this action may not be detected at all, although Groscurth and Bansi[47] noticed, after an intravenous injec-

tion of metrazol up to 100 mg., a transient increase in stroke volume. Metrazol seems to have no effect upon the isolated striated muscle (Stross[109]), but in the whole animal (frog) it has a defatiguing effect (Fischer[39, 39a]). Since in his experiments the nerve connections of the muscle were severed, the action is explained as being due to an improvement in circulation and oxygen absorption. This was observed in cold and warm-blooded animals.

Metrazol attracted special attention after the 1931 German Himalaya expedition, when one of the participants collapsed and could proceed only after taking this drug every two hours.[49]

Majdrakoff [75] gave metrazol to 400 persons, including hikers, skiers, mountain climbers, bicyclists, and soccer players. There was a definite improvement in endurance, and in exertion over a short period; the respiration and blood circulation was improved. In hiking and skiing, the metrazol was given 2-3 hours after the beginning of the activity, and in soccer it was administered between the halves of the game.

The drug has been used by Swiss physicians in mountain climbing clubs. Hartwich [49] who is a foe of "doping" gives metrazol to skiers after they have reached the peak of the ascent in order to ward off fatigue.

It was impossible to obtain the original article by Majdrakoff, and the reference was taken from Baur's article. There was no indication that experiments were controlled in Majdrakoff or in Hartwich's work. *A priori* any investigator with experience in this type of research would doubt the reliability of conclusions based on activities in which the energy output may vary a great deal.

Experiments with metrazol are now in progress in the writer's laboratory.

OXYGEN

One of the main limiting factors in physical activities is the amount of oxygen which can be taken up by the organism. Therefore it seems logical to suppose that if one breathes pure oxygen it will increase his capacity for exertion and recovery.

Pembrey and Cook [92] observed that after exercise it was easier to breathe oxygen than air. Hill and Flack [59] reported that when oxygen was given for three minutes immediately before the exercise and also for four to five minutes during recovery, the athletic performance was improved and the recovery from fatigue was quickened. Douglas and Haldane [35] compared the effect of forced breathing of ordinary air with that of quiet inhalation of oxygen, and found forced breathing more helpful than oxygen inhalation before stair-running. Hill and Mackenzie [60] repeated the experiments and found the opposite to be true; Hill and Flack [59] found that a man holding his breath was able to run 470 yards after oxygen inhalation. Moreover, Feldman and Hill [38]

noticed that preliminary oxygen inhalation resulted in lower lactic acid accumulation, and also stated that the effects of preliminary oxygen inhalation may last as long as 15 minutes. Karpovich [64] found that 2 minutes after oxygen breathing there was only 20.3 per cent of that gas in the expired air. Miyama [85] reported that preliminary oxygen breathing was beneficial before a 120-m. run and also to recovery after that run. Unfortunately in his test the effect of "warming up" and also "getting used" to peculiarities of the run in a long corridor had not been eliminated. His decisive experiment consisted of testing two men. Both of them ran faster after several trials, whether oxygen was inhaled or not, and the degree of improvement was about the same. Simonson et al.[104] noticed that the effect of preliminary running for about 2 minutes with moderate speed before a 100-yard dash had a definite beneficial effect. However a preliminary inhalation of oxygen, in spite of some favorable sensation, had no effect upon the speed. Karpovich [64] experimented with a preliminary oxygen breathing immediately before the start in a 100-yard swim. There was definite improvement in speed. Obviously this was due to the ability to hold the breath longer while swimming.

A suggestion has been made that athletes would be able to exert themselves to a greater extent in an atmosphere rich in oxygen. Nielsen and Hansen,[88] experimenting with subjects riding bicycle ergometers, found this to be true only when the rate of work became very strenuous.

In conclusion: Oxygen breathing immediately before a short swimming race, during strenuous work, and during the first few minutes of recovery is beneficial. Since there is no storing up of oxygen, the preliminary 3 deep inhalations of oxygen are just as effective as prolonged breathing; and since the effect of preliminary oxygen breathing wears out in 3 minutes, there is no basis for the assertion that Japanese victories in swimming were due to oxygen breathing. Forced breathing of ordinary air on the start enriches the lungs with oxygen, and therefore should be helpful, especially before sprinting events.

PHOSPHATES

Phosphates are indispensable to physical activities, because the break-up of phospho-creatine furnishes the energy for muscular contraction, and because phosphates also function as buffers in the blood.

Embden and his associates[37] used chiefly sodium phosphates in the form of recresal, and reported a 20 per cent increase in working capacity in ergometric tests. Sham feeding was used to eliminate any psychological effect. The phosphates also appeared to be beneficial to soldiers and coal miners. In addition to a greater work capacity, the subjects also experienced a sense of well-being and elation. These results were obtained with daily doses of 3 grams; larger doses may

cause insomnia and other disturbances. Flinn [40] repeated Embden's experiments on industrial workers, and although he found no increase in work output, he noticed that many felt better, especially those who previous to the experiment had been subject to chronic constipation. Since phosphates were a mild laxative, they helped in producing "regularity" and a feeling of well-being.

A better performance and a lesser degree of fatigue were observed in weight lifters and 3000-meter runners by Herxheimer.[56] Puni [86] confirmed most of the work of Embden, and found that a small dose of phosphate taken one to three hours before a psychomotor or motor test increased the endurance of the subject. Atzler,[2] using the phosphate preparation sanatogen, also noticed an improvement in muscular work. Poppelreuter [94] used phosphates on himself for a whole year, and claimed that there was definitely an improvement in mental and muscular work. A slight increase in muscular work was also reported by Nothaas.[89] Loewy and Eysern [71] experimented with evianis, a drink containing phosphorus, and noticed a quicker recovery after exercise and sometimes less fatigue. In addition to the negative findings by Flinn,[40] Schorn [102] also noticed no effect of phosphates on either muscular or mental work, and he explained the results of Poppelreuter on the basis of autosuggestion. Marbe [76] also pointed out the possibility of a psychological effect, for in his experiments a drop of congo red in distilled water had the same effect as three to five grams of recresal. Krestovnikov [68] and his coworkers could not discover any definite effect of phosphates after a three-month intake, except a questionable shortening of the recovery period. Nor could Morse [86] observe any remarkable effect of phosphates on dogs running on a treadmill.

The preponderance of evidence seems to favor the idea that phosphate preparations are beneficial. Yet aside from rather doubtful conclusions presented by Herxheimer there is no definite proof that administration of phosphates was responsible for improved performance in sports and athletics.

SODIUM CHLORIDE

It has been known for a long time that profuse sweating, causing a large loss of sodium chloride, may lead to muscular cramps. Sweat contains from 0.05 to 0.5 per cent sodium chloride, and it is possible to lose from 3 to 30 grams of salt per day. Since the average intake with food is 10 to 20 grams daily, it is clear that excessive sweating may cause a serious depletion of body sodium chloride.

Cassinis and Adilardi [18] reported a beneficial effect of salt during long military marches. Dill [30] contributed a great deal to knowledge regarding the importance of sodium chloride, and he has been instrumental in the promotion of the prophylactic use of 0.1 per cent salted water in industries where sweating is profuse. This resulted in a practical prevention of "heat" cramps. On Dill's initiative, football

teams began using well-salted bouillon and salt tablets, with favorable results. Of interest is the experience of a southern football team, whose fall practice cramp epidemic disappeared when more salt was taken by members of the team.

Many coaches erroneously believe that salt tablets can be responsible for extra energy and endurance in athletes in general. Unfortunately this is too much to expect. Addition of salt to the diet is only a precautionary measure to insure a *normal* output of energy, which may be lowered if there is excessive loss of sodium chloride.

Salt is advisable for athletes, especially at the beginning of the season, except for those who usually like and take salty food.

SUGAR

Sugar furnishes the fuel for muscular contractions, and this fact has been responsible for its use by athletes. Quantities taken per day vary a great deal; some coaches have attempted to give up to one-half pound of sugar, causing a severe gastric disturbance. The usual intake is a few lumps of cane sugar, a few tablets of dextrose, or two spoonfuls of honey.

Gordon et al.[44] observed an improvement in the condition of marathon runners after sugar administration. Carpenter and Fox[17] reported that when glucose ingestion is accompanied by long work, some of the glucose is utilized, but fructose is probably converted into fats. Dill and associates[32] found that glucose given during prolonged work lessened fatigue. Vogler and Ferguson[112] claimed that when 4.8 grams of dextrose, equivalent to one cube of sugar, was given for two days, the speed in a 40-yard dash and muscular strength as tested by dynamometer increased. Pampe,[91] however, could not observe any favorable effect of the ingestion of 50 to 100 grams of sugar upon muscular work. Numerous tests by the present author showed no effect of sugar in tests of short duration, such as swimming 100 yards or riding a stationary bicycle for 1 to 3 minutes at 0.5 H.P. The tests were negative for glucose, cane sugar, and honey.

The use of sugar is most indiscriminate, and has no physiological support except when given during prolonged exercise. The beneficial effect of sugar given before a test of short duration may be ascribed to a psychological influence. Although Vogler and Ferguson attempted to eliminate any psychological effect, yet it is inconceivable that 4.8 grams of sugar, which constitutes about 1 per cent of the total daily carbohydrate intake, can be physiologically responsible for an improvement in muscular work. In experiments of this type it may be advisable to eliminate psychological factors affecting the investigators themselves. The tested substance and the substitute should be given in such a manner that the person who actually tests the subjects, does not know what is being administered in each case.

ULTRAVIOLET RAYS

The effect of ultraviolet rays has been tried on runners and swimmers (Hering [55] and Heiss [50]), on oarsmen (Lade [69]), on stationary bicycle riders (Lehman and Szakall [70]), and in experiments with an ergograph (Backmund [5]). All reports indicate a beneficial effect of irradiation upon muscular performance and general well being. The explanations for this are not clear, and vary from a mere "psychological" effect to an action through the central nervous system leading to a definite increase in vagotonus.

VITAMINS: B(complex); B_1; and C

Most of the known vitamins are indispensable to normal existence, and the disastrous results of their lack are evident in pellagra, rickets, beri-beri, scurvy, and other avitaminosis diseases. The rapid improvement from such conditions upon administration of a small amount of the needed vitamin dramatically illustrates how little of the substance is needed and how powerful is its action.

There are also many cases of border-line vitamin deficiencies. Although the symptoms are not as definite as in the case of prolonged complete absence of vitamins, nevertheless, many bodily functions become abnormal and physical fitness is lowered. Administration of needed vitamins is followed by marked improvement. It is possible that improvement in these border-line cases is responsible for the popular notion that *excess vitamin* intake by normal people will increase their well-being.

Vitamin B(complex).—An increase in muscle and liver glycogen of rabbits fed on concentrated yeast was found by Bickel and Collazzo.[9] Sugar storage may be increased if yeast is given with small quantities of sugar, but if large quantities of sugar are given, no relationship can be observed (Aida [1]). According to Pi-Suner and Liss,[93] yeast feeding increased the capacity for muscular work. Csik and Benesik [23] experimented with vitamin B extract on two subjects using the ergograph, dynamometer, weight lifting, and treadmill tests. Although an increase in work capacity was noted, the results are nevertheless doubtful, since the effect of training was not completely isolated.

Vitamin B_1.—Hard-working men, and athletes, should have more than 300 International Units of Vitamin B_1 daily, yet Stiebeling and Phipard [108] reported that a large number of people in the United States live on a diet poor in this essential. Williams et al.[114] gave their subjects .95 mg. of vitamin B_1 per day. Although the patients appeared to be normal, yet their capacity for work was lowered. A double amount of this vitamin practically doubled their work capacity. McCormick [78] claimed that a daily administration of 5 mg. of vitamin B_1 (1665 International Units) increased speed and endurance in swimming. One week of administration of this daily dose of vitamin B_1 slightly in-

creased the breath-holding capacity, and greatly increased endurance in static work (holding arms steadily outstretched). Karpovich and Millman,[64a] using sham feeding, repeated McCormick's experiments on a large number of subjects, and could not notice any beneficial effect. Of special interest were two subjects, who were on a diet definitely poor in vitamin B_1. One of them held his arms outstretched for 4 hours and 20 minutes, without any preliminary vitamin B_1 feeding. It is possible that neither arm holding nor breath holding are adequate tests for the effect of vitamin B_1.

Vitamin C.—When symptoms of scurvy developed among students of a school of physical education in Russia in 1920, the present author observed a sharp decline in athletic performance. This is in agreement with the findings of Schroll [103] that a lack of ascorbic acid in the diet of guinea pigs produced a more rapid onset of fatigue and a greater accumulation of lactic acid in the blood. Ratsimamanga [97] demonstrated that administration of ascorbic acid favors the deposition of glycogen in muscles and in liver. No experimental evidence could be found showing that excess of vitamin C in any way affects muscular performance.

It is clear that a lack in vitamins B and C cause a drop in physical fitness and in athletic performance. Since a possibility of a lack of Vitamin B_1 is always present, it would seem to be a good idea to administer it in all doubtful cases; a marked improvement in physical condition may be the result. There is no adequate evidence that excess vitamin supply would increase athletic performance.

CONCLUSIONS

In the present brief review the following "ergogenic aids" were considered: 1) Alcohol; 2) Alkalies: calcium, bicarbonate of soda, sodium and potassium citrate; 3) Ammonium chloride; 4) Benzedrine; 5) Caffeine: coffee and tea; 6) Cocaine; 7) Coramine; 8) Digitalis; 9) Gelatin and glycine; 10) Fruit juices; 11) Hormones; 12) Lecithin; 13) Metrazol; 14) Oxygen; 15) Phosphates; 16) Sodium chloride; 17) Sugars; 18) Ultraviolet Rays; 19) Vitamins.

There are few of these substances that have an ergogenic action. The most powerful are hormones, caffeine, and cocaine. With the exception of caffeine as found in tea and coffee, consumed in moderation, the use of these substances is dangerous and should not be encouraged. According to present knowledge of these drugs, they have no practical application except for therapeutic reasons. Alkalies have been found effective in quiet laboratory experiments, but so far have failed to show their influence upon muscular exertions involving emotional stress.

Many substances are helpful only when they are used to replenish a previous lack, or as a precaution for a possible depletion during work. To this group belong sugars, sodium chloride, and vitamins.

Oxygen is helpful during strenuous work and in the following recovery period. If inhaled before a sprint, it enables one to hold the breath longer and to move faster.

Some substances should be considered as questionable aids for normal people. Among them are benzedrine, coramine, and metrazol. Others definitely have no ergogenic effect in normal persons, such as ammonium chloride, digitalis, gelatin, and glycine.

Artificial light exerts a beneficial effect upon muscular performance, but further studies are needed to determine "why" and "how" this is brought about.

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CHAPTER XI

Longevity and Athletics

By Peter V. Karpovich

WHENEVER a formerly outstanding college athlete dies from a cause other than old age it immediately becomes news, which focuses public opinion on the question: is participation in strenuous athletics harmful? Physical directors and coaches usually take it for granted that physical education and athletics help in prolonging life. There are, however, many people who, admitting that moderate indulgence in exercise is hygienic, believe that participation in strenuous athletics is definitely harmful and shortens life. It would, therefore, be of practical importance to review this question.

It is common knowledge that the average length of life has been increased greatly in recent years. Whereas in Roman times it was between 20 and 30 years, it reached 34.5 for the years 1755-1770 in Sweden. By 1816-1840 it had reached 41.5; in 1911-1920 it exceeded 60. In the United States today the life expectancy for men and women is 62 years. Dublin[6] says that the maximum span of life is about 100, and it should be possible in the future to reach an average length of life of 75 years.

The remarkable achievement of prolongation of life has been made possible through the progress of medical science, which has resulted in improved hygienic conditions and an efficient fight against communicable diseases.

Analysis of the causes of death in the United States shows that the communicable diseases have moved down from the head of the list and that cardiovascular-renal diseases and cancer have replaced them as leaders. This increase in heart disease is interpreted as an effect of the strain of modern life upon this vital organ. A great deal has been achieved in management of the cardiac patients. Although little can be done to prevent the development of heart disease aside from sparing the heart during and after the course of the illness, nevertheless a strict regulation of the activities lengthens the lives of these patients.

The cause which stands next in importance to heart disease is cancer. Its position may be due to the present better diagnosis and statistical reports. As to the prevention of this disease, nothing practical can be offered, since even the nature and the cause are yet but vaguely understood.

In the third position on the list of causes of death stand influenza and pneumonia. The trend of present research indicates that science is on the right path to conquest of these diseases.

Accidents occupy the fourth place. We say fatalistically: "Accidents will happen." But this is a rather callous and non-realistic attitude. Most accidents are preventable. Experience with industrial accidents dramatically illustrates that this can be accomplished. The next step in prevention is to reduce the needless and criminal loss of lives from automobile accidents. There is proof that it can be done. Safety education combined with fear of losing a job and rewards for good records have greatly reduced the number of accidents among the truck and bus drivers. A more active organization among drivers in general, with stiffer tests and heavier penalties, should also be effective.

Among the factors shortening the life span, obesity should be singled out for attention. Although it is not listed as a direct cause of death, it is closely related to other diseases, such as heart disease, diabetes, apoplexy, kidney, and liver disease. "For every inch which a man's waist measure exceeds his chest measure, subtract two years from his life expectation." [2] It seems that after one reaches thirty-five, it is wise to avoid overweight.

The question is often raised: does a greater degree of general physical prowess mean longer life? Material collected by the insurance companies has failed to show any relationship on the positive side. It is only when some pathological symptoms are found that their detrimental effects begin to affect life expectancy. Otherwise, if the organs and functions are apparently normal, predictions would be the same for the same age and occupation no matter how much difference in some other aspects of general physical fitness there could be. This leads to the conclusion that there is one more kind of physical fitness—fitness for a long life. This fitness for longevity is undoubtedly related to heredity. Pearl and Pearl [12] have shown that long-lived people usually had one or both parents who also lived long.

ATHLETES

The first attempt to study this problem of mortality among the athletes was made by Morgan.[11] He compared the length of lives of men who rowed in Oxford and Cambridge races between 1829 and 1859 with the life expectancy of the average Englishman at that time. The conclusion was that the oarsmen exceeded by two years the allotted span of life.

In this country Meylan[10] undertook to find out what has become of the former Harvard oarsmen who rowed from 1852 to 1892 inclusive. Of 123 men still living in 1902 Meylan personally examined 76, and the others were examined by their family physicians. His conclusions were that the Harvard oarsmen were better risks than the rest of the insured group. Their life expectations were on the average five years longer. There was no evidence that heart disease took any extra toll among them. The living members of the crews evidently enjoyed good

health because out of 106 men reported 97 men had no complaints to make.

Hartley and Llewellyn[9] investigated the life stories of 767 Cambridge and Oxford oarsmen who rowed at some time between 1829 and 1928 inclusive and came to the same conclusions as Meylan.

Anderson[1] found that the mortality among the Yale students who attended that college between 1855 and 1905 was lower for the athletes than the non-athletes. Greenway and Hiscock[7] analyzed the causes of death among the Yale athletes, and found that the per cent of death from tuberculosis and heart disease was lower among the athletes. On the other hand, the per cent of death due to various accidents, including war casualties, was greater among the athletes.

Hahn, Herxheimer, and Brose[8] examined 50 old athletes who were outstanding in their youth. They could not find any pathological changes which could be ascribed to vigorous athletic activities.

Of special interest is a study made by Dublin.[3, 4] He studied ten eastern colleges; 4976 men were included in this investigation as graduates prior to 1905. The sports covered were football, baseball, rowing, track and field, cross-country, lacrosse, basketball, and hockey. For comparisons he used two insurance tables: the Medical-Actuarial Table which represents the experience of all the large insurance companies during 1885-1909, and also the American Men's Table of Mortality which covers the years between 1900-1905. It was found that the mortality rate among the athletes was lower than expected. Compared with the Medical-Actuarial Table of Mortality, the rate was 6.8 per cent lower. In comparison with the American Men's Table it was 8.5 per cent lower. This means that the athletes are better risks than the average man. It also has been established that the death rate declined sharply among the more recent graduates. For instance, classes graduating after 1900 have a death rate of only 72.6 per cent of the expected rate.

The highest mortality rate was in the baseball group. The second highest mortality was the oarsmen. The trackmen's rate was about the same as the average for the whole group. The football men gave the best showing of those engaged in single sports. Their death rate was only 88.3 per cent of expected, but this was surpassed by men engaged in two or more sports. Their death ratio was 78.3 per cent.

Dublin divided his men according to their ages; one group younger than 45, and the other older. The results were quite striking. Crew men under 45 have a mortality of from 20 to 40 per cent above the average for insured men and from 40 to 65 per cent above the mortality of other athletes. After 45 years of age the mortality rate among the oarsmen was the same as among the others. Football men after 45 showed a greater mortality rate than the track athletes. According to Dublin's study, athletes after reaching the age of 45 showed an in-

crease in death rate from heart disease. This increase was about 12 per cent over the expected figures.

As it is seen, Morgan, Meylan, and Hartley, and Llewellyn found that oarsmen do not die young. On the other hand, Dublin found that mortality among the oarsmen before the age of 45 is greater than that for the other men. He also found that the mortality rate among the former college baseball players was higher than for the other athletes. This is confusing and throws a doubt upon the validity of at least some of his findings. Maybe this was peculiar for this particular group of baseball players and would not be true of the other group. It would be of great interest to make a careful analysis of the causes and rate of mortality among the professional baseball players.

The weakness in these studies was the fact that college athletes were compared with the average insured persons. It has been definitely established that college graduates are better insurance risks than men who do not attend college. This weakness was corrected by Dublin[5] who investigated the life histories of 38,269 graduates of ten Eastern colleges, who attended college from 1870 to 1905. He found that up to 50 years of age the mortality of an athlete is the same as that of the other college graduates, but after 50 it is slightly increased.

Dublin also found that the length of life of an athlete is slightly less than that of the average graduate and that the honor students live longer than the average students, so that an honor student lives two years longer than an athlete. Dublin says that perhaps an athlete is not predestined for a long life. Upon discontinuing his regular training, he has a tendency to put on weight which shortens his life. He is also a more physically adventurous man, who is likely at times to take undue chances believing in his superior health, strength, and agility, thus exposing himself to unnecessary risks. It is a common thing to see some former athletes who have passed the prime of life engaging in strenuous games with much younger opponents. The adage that "one is as old as he feels" is a dangerous rule to follow.

The non-athletes who may be small and physically less fit may outlive the more physically vigorous men, by taking better care of themselves and avoiding risks.

In conclusion it may be said that more is known about how to prevent shortening of life than about how to lengthen it.

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CHAPTER XII

Cardiovascular-Respiratory Function in Relation to Physical Fitness

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NATURE AND SCOPE

RESEARCH workers in physiology of exercise may be classified on the basis of their interests into two groups: (1) those interested in the physiologic mechanisms of the body and their normal and abnormal function, (2) those interested in the action of these mechanisms while the body is "at muscular work," or the effect of "muscular work" in modifying function. This latter information is used to determine the "physiologic characteristics" of various athletic, military, or occupational groups for predictive purposes. This information relates to permanent effects or effects of long continued specific muscular activity, and temporary changes or changes during participation in the activity. The latter is of little value for predictive purposes.

In the realm of applied research, circulatory-respiratory measures have been used by research workers and health and physical practitioners in the assessment of "physical fitness." * A statement such as, "The body at work is only as good as the function of the heart" describes the philosophy of these workers. The confusion in the use and interpretation of these measures as an index of physical fitness can be described as, first, the evaluation of "physical fitness" without knowing the constituent phases of physical fitness or assuming that they are measured by use of circulatory-respiratory tests; second, the use of circulatory-respiratory variables or tests without knowing what constitutes a valid index of circulatory-respiratory function.

In evaluating circulatory-respiratory measures as indicators of physical fitness it is first necessary to determine what kind of fitness is to be evaluated. Fitness for endurance differs from that for a sedentary occupation. In the latter, great demands are not placed on these functions. A person may not enjoy the "benefits" that go with circulatory-respiratory function in the highly trained, but he may enjoy, equally well, work and leisure of a different kind. Following the broad definition of physical fitness, that of adaptation, the individual in a sedentary occupation is physically fit although the circulatory-respiratory measures may deviate considerably from the normal.

The confusion in the findings resulting from the application of cardio-

* Items used are: reclining, sitting, and standing pulse rate; systolic, diastolic, and pulse pressures; reaction of pulse rate; systolic, diastolic, and pulse pressures during and after exercise; breath-holding normal and after exercise; vital capacity; and combinations of cardiovascular-respiratory variables in test batteries.

respiratory tests is due to the relative incompleteness of these tests as an index of circulatory-respiratory function, and also to the relative degrees of validity of the variables and tests in respect to the kind of physical fitness to be evaluated. Of approximately twenty constructed cardiovascular tests, some have been and some are being used as valid indexes of circulatory-respiratory function, yet they include different *unrelated* measures of these systems. The problems facing experimenters are two; first, what are the "group components" or the basic underlying mechanisms of the various circulatory-respiratory measures, and second, what is the relative validity of each "group component" in terms of degrees of physical fitness. There is some evidence on these questions although the final answer cannot be given. There is *real need* for careful experimental work involving the physiologist and the statistician.

Utilizing the direct, indirect, and after-exercise circulatory-respiratory measures, there are from twenty to thirty measures depending upon the number of after-exercise tests given.* Many of these "vary together" and have for their cause the same mechanism. The regulating mechanism can be determined experimentally only by observing the action in the living organism. This, of course, is difficult to do; therefore the second method, namely determining what measured functions "vary together." With the help of the physiologist the reason (either in the form of a fact or a hypothesis) for the "going-togetherness" can be advanced. There have been four studies of the latter type [16, 17, 21, 31] attempting to determine the physiologic variables that "vary together." These studies are limited in a number of respects: (1) inadequacy of sampling—these have been one-institution samples with relatively few subjects; (2) the experiments did not include a complete number of measurable circulatory-respiratory functions; (3) the "group components" (highly correlated variables) resulting are only as good as the validity of the measurement device and the validity of that device as a "complete index" of circulatory-respiratory function. In the latter, (3), neither of the two assumptions is completely fulfilled.

Three of these studies were on men of the college age range [16, 17, 21] and one on college women.[31] Because of the physiologic variations of the prepubescent, pubescent, and postpubescent individuals, these results are applicable only to the college age range and in respect to the limitations stated above.

McCloy [21] found eight "group components or physiologic mechanisms," three describing the pulse rate, and five describing blood pressure. Larson [17] also found eight components although his battery of variables was different from those selected by McCloy. Breath-holding after exercise and vital capacity were not included in the McCloy battery. Five of the components describe the blood pressure, two the

* See footnote, p. 456.

pulse rate, and one the respiratory function. Larson's study has been substantiated on Springfield College men.[33] Murphy[31] found nine components, three components related to heart rate, two with blood pressure, one with hydrostatic pressure, and three with the redistribution mechanism of the blood related to changes in the hydrostatic pressure. Further experimentation is needed to verify the above findings as well as the "experimental validation" of each mechanism against an objective criterion of physical fitness to determine the relative degrees of validity.

FACTORS INFLUENCING CIRCULATORY-RESPIRATORY MEASURES*

Factors influencing the normal pulse rate, other than exercise, are age, sex, diurnal changes, season and climate, altitude, air and water movement, loss of sleep, respiration, metabolic activity, changes in body posture, digestion, and emotional or nervous factors.

The heart rate is more rapid at birth (130–150) but gradually decreases in the normal child with age (80–100) at 3 years and 79–90 at 12 years.[46, 32] There is a slight decrease in pulse rate with age beyond the 12-year period in boys[9] until approximately the 18-year period when pulse rate does not correlate with age.[22] During these pubertal periods the heart rate is slightly faster for girls than for boys.[23, p. 51] The normal pulse rate is lower in the morning than in the afternoon.[42] The heart rate increases with altitude because the demand placed on the circulatory mechanism for oxygen is greater,[43, 40] and the time necessary for recovery to normal is increased.[38] Air and water movements about the body increase the pulse rate.[20] Loss of sleep increases the exercise pulse rate.[5, 52] Low oxygen tension increases heart rate as does increase in carbon dioxide tension.[44, 19] The heart rate is increased as the body is changed from lying, sitting, to standing positions.[39] The heart rate also changes with emotions or nervous conditions.[23, p. 56] Candidates for physical examination, enlistment, or induction frequently have a heart rate above their normal.

Systolic, diastolic, and pulse pressures are influenced, not only by exercise, but also by age, time of day, climate, sleep, height and weight, respiration, digestion, metabolism, drugs, position of the body, and nervous or psychic factors. The normal range for young adults is: systolic: 110–125 mm. Hg; diastolic: 65–90 mm. Hg; pulse pressure: 35–55 mm. Hg; capillary: 15–40 mm. Hg; and venous: 3–20 cm. H_2O.[23, p. 66] Garner[11] gives five factors maintaining normal pressure: (1) heart beat force, (2) resistance in vessels, (3) blood volume in vessels, (4) viscosity of the blood, and (5) elasticity of vessel walls.

The literature summarized shows a gradual increase in systolic

* The two following sections will be limited to two physiologic discussions, namely, the factors other than exercise influencing circulatory-respiratory measures and the permanent effects of training. The temporary changes during muscular activity participation are omitted.

(70–85 at one year to 110–130 at maturity), diastolic (50–60 at one year 70–80 at maturity), pulse pressure (20–30 at one year to 30–40 at maturity), and venous pressure (8 cm. at 5 to 24 cm. at 55–65) with age in normal individuals, the more physiologically mature within each age having higher values.[23, pp. 70-78] The systolic pressure and pulse pressure gradually increase during the day with a slight fall in diastolic.[51] The venous pressure also gradually increases with the time of the day.[14] The systolic and diastolic pressures are lower in hot climates.[6] During sleep the systolic and diastolic pressures fall, with a gradual return to normal with normal waking.[15] The systolic pressure, according to Barry, rises during expiration and falls during inspiration.[2] Factors causing these variations are heart rate, negative pressure in thorax, and intra-abdominal pressure.[12] Digestion causes a rise in systolic, diastolic, and pulse pressure to a maximum one-half hour after food.[51] During excitement the systolic and pulse pressures increase with marked variations in individuals.[30] Changes in the position of the body from reclining to sitting to the standing position cause an increase in diastolic pressure in normal healthy individuals, with no significant change in systolic except for men 50–60 years of age, where there is a slight drop.[37] Taller and heavier girls have higher systolic and diastolic pressures.[3] Emmes and Riche [8] found an increase in metabolism in the sitting position as compared with the reclining. Main notes a decrease in alveolar CO_2 in the standing position.[29]

EFFECTS OF TRAINING ON CIRCULATORY-RESPIRATORY FUNCTIONS

Schneider claims that the effects of a sedentary occupation are reduction of muscle tone, decrease in appetite, constipation, shallow breathing, and slow circulation, which are characteristic of the inefficient, and can be offset by physical activity. Bainbridge [1] agrees with Schneider and adds that exercise increases the metabolic activity of the body and that, because this is particularly important in the development of the skeletal muscles, the heart, and the lungs and other structures of the body, exercise should be part of the program of all, and in particular of youth.

The literature up to 1933 * on the training effects of exercise on circulation has been reviewed and interpreted by Steinhaus.[47] He utilizes the evidence available to show the changes accruing from exercise participation. Dill, Hellebrandt, and Steinhaus in their summaries in the *Annual Review of Physiology* report some research on the permanent effects of exercise or the modifications in function resulting from participation. Steinhaus [47] states that there is hypertrophy of the heart as the result of endurance exercise and quotes Harey as saying that "the more muscular and powerful men are, the firmer their flesh; the stronger,

* Later reviews are those by Dill, Hellebrandt, and Steinhaus in the three volumes of the *Annual Review of Physiology* (1939–1940, 1941).

thicker, denser, and more fibrous their hearts; the thicker, closer, and stronger are the auricles and arteries."

Roberts, et al.[35] found that, although in a normal growing heart the capillaries increase along with the increase in fiber size, in hypertrophied heart the ratio of capillaries and fibers remained like that of the normal (1.4 normal; 1.3 hypertrophied). The trained athlete has a lower resting pulse rate and the trained heart accelerates less in exercise or when assuming the upright position. Steinhaus cites perfect agreement in the literature that the trained individual has a larger minute volume at rest as compared with the untrained (minute volume = pulse rate × stroke volume). He also comments that because the pulse rate is lower in the trained the stroke volume must be larger. This statement has been substantiated by Schneider and Crampton.[41] The evidence according to Steinhaus on the effect of training on the minute volume determined during work is not in the same agreement. He quotes a research combining nine experiments in which there is an agreement for the existence in general of a linear relationship between cardiac output and oxygen consumption ranging from 200 to over 4,000 cm. per minute, but this does not hold for all work levels or for different degrees of training. In the study of oxygen consumption of distance runners it was found that Lash reached an oxygen intake of 5.35.[36] Compared to his basal metabolism this means that he increased his metabolic rate 21.4 times. Compared to the maximum of the best untrained individual it is 14.5 times greater. The authors conclude that the high O_2 intake which can be attained by these men is due largely to extremely high cardiac output, since their blood is normal in O_2 carrying capacity. Steinhaus[47] cites two studies showing higher oxygen utilization and correspondingly lower minute-volumes for a given oxygen consumption, after training. McNelly[28] found in comparing trained and untrained men on the bicycle ergometer that in the trained the R.Q. was lower, with a smaller rise in the quotient during exercise and recovery, the oxygen debt smaller, and that the percentage of O_2 removed from the inspired air was greater. He found no improvement in mechanical efficiency. Stewart and Watson[48] found, in comparing athletes and non-athletes under basal conditions in respect to arteriovenous oxygen difference, oxygen consumption, minute volume output, stroke volume, vital capacity, cardiac size, circulation time and venuous pressure, arterial pressure and heart rate, that with one exception there was no significant difference between athletes and non-athletes. The stroke volume in athletes was slightly larger. Steinhaus[47] cites studies showing no change in blood pressure as the result of training, but it is pointed out that the training activity in these studies was comparatively mild or the training period of short duration.

In the studies by McCurdy and Larson[22] the standing pulse

pressure for the athletic group (Olympic-swimmers (*40*) and Springfield varsity swimmers (*60*) was higher ($M = 38.20$ for Olympic and $M = 36.20$ for Springfield) than the afebrile infirmary group examined before release ($M = 29.19$, $N = 138$). It was found in the same experiment that the sitting diastolic pressure for the athletic group ($M = 78.00$ for Olympic, and $M = 72.00$ for Springfield) was significantly *lower* than in the infirmary group ($M = 88.72$). In an experiment on the same subjects (73 examined before commitment to the infirmary—in good health—and again just before release from infirmary in an afebrile state) the sitting diastolic pressure increased significantly ($M = 72.20$ to $M = 89.10$) and the standing pulse pressure decreased ($M = 37.20$ to $M = 29.20$).[24] The sitting systolic pressure increased slightly ($M = 115.30$ to $M = 121.40$). In a study of 27 subjects examined before training for swimming and again after mid-season peak in training, it was found that the sitting diastolic pressure remained unchanged ($M = 77.80$ to $M = 77.30$), the standing pulse pressure remained unchanged ($M = 40.30$ to $M = 40.70$), and the sitting systolic increased slightly ($M = 122.50$ to $M = 129.20$). These men, however, were in "good condition" before beginning the training program for swimming.[24] It is generally considered a sign of fitness if the systolic pressure remains unchanged or rises slightly while changing from the lying to the standing position. The Schneider and Crampton tests utilize the systolic pressure in this way. It was found by McCurdy and Larson in examining 100 highly trained athletes (40 Olympic swimmers and 60 Springfield College varsity swimmers) that the mean standing systolic was lower than the mean reclining pressure ($M = -2.32 \pm 0.92$). This finding is common experience among those who have used these tests.

Steinhaus[47] states that there is agreement that vital capacity increases with training. In the experiments conducted at Springfield College on cross-country men and swimmers before and after training, the vital capacity increased only slightly. It should be remembered that in both experiments the subjects were in "good condition" before the experiment and that the time for the experiment was for about three months.[24]

It has been found that breath-holding after exercise increased slightly, but probably not significantly, with training for swimming, and that there was a slight decrease with respiratory infection, which is also probably not significant.[24] This may be due to improvement in ventilation, improvement in buffer action of the blood, and change in the minute volume. Dill[7] cites a study of Simonelli and Ferri showing that training doubled the ability to hold the breath and that a higher alveolar CO_2 was tolerated.

VALIDITY OF CARDIOVASCULAR-RESPIRATORY VARIABLES AND TESTS

Two problems arise whenever one interprets the validity of a measure: first, the theoretical validity, or is the function actually measured, and second, the practical validity, or the significance of the function in terms of some objective criterion. In this paper the objective criterion is "physical fitness," and the question is to what degree are these measures predictive of physical fitness changes. The evidence reported by Steinhaus, Dill, and Hellebrandt in their review of the recent literature shows the effect of changes through exercise. To what degree these items have predictive value is shown by studies conducted by Flanagan,[10] Henry and Kleeberger,[13] and McCurdy and Larson.[25] These studies, however, did not begin with all measurable items of the circulatory-respiratory systems.

Flanagan[10] found in his study that the pulse-ratio test, based on the ratio of the normal pulse rate divided into the pulse rate for two minutes following exercise, correlated —.52 with the "endurance index" for the 220-yard run. The "endurance index" is the time for the 220-yard run divided by the time for the 60-yard dash. He found that by dropping nine subjects from the original 57 because they deviated from the regression line, the correlation increased to —.89. He justified the dropping of the nine subjects on the basis that five were untrained and unconditioned and four were distance runners.

Henry and Kleeberger[13] repeated this experiment using the "endurance index," or the time for the 70-yard run divided into the time for the 220, in addition to a step-climbing test. They confirmed the —.50 correlation found by Flanagan but questioned the —.89 correlation. They found the correlation of —.46 with the "endurance index" with the influence of speed eliminated dropped to —.42. When they combined the two criterion measures (endurance index and step climbing), the correlation with the pulse-ratio test was —.64; with the body weight factor eliminated, —.44. These experiments showed that the trend for better endurance is associated with a lower normal pulse rate and less affected pulse rate after exercise.

McCurdy and Larson[25] found that by combining the standing diastolic pressure, breath-holding 20 seconds after exercise, vital capacity, and sitting pulse pressure divided by sitting systolic pressure, not only did these measures significantly differentiate between conditioned endurance swimmers—Olympic and varsity—and afebrile infirmary patients (.7018) but they also correlated .6772 with the "time" for the 440-yard swim. These studies show that circulatory-respiratory condition is significant when the exercise reaches the endurance state. As stated by Steinhaus[47] these functions are not significantly changed until the exercise is vigorous and of long duration. In the McCurdy-Larson experiment, good swimming time is associated with the higher standing

diastolic pressures, the higher breath-holding 20 seconds after exercise abilities, the higher vital capacities, and moderately higher sitting pulse pressure divided by sitting systolic pressure values.

PROBLEMS OF MEASUREMENT

Reliability and Objectivity.—Schwartz, Britton, and Thompson[45] from their study on the reliability of blood pressure measures, concluded that the reliabilities were not sufficiently high to render tests, including these measures, valid. The reason for lower reliabilities than those found in other experiments is found in their administration of the reliability experiment. The first measures were secured in February, the second in June. Reliability determinations of circulatory-respiratory measures must be made during the same day because of factors (diurnal, seasonal, exercise, etc.) causing variations. Rickey[34] in his study on 1147 children compared the mean reading of two examiners and found the means approximately alike (systolic 105.64, 105.26; diastolic 67.05, 67.65; pulse pressure 37.51, 37.74). These similar values might imply perfect correlation, which of course is not true. The means are group means and do not express the deviation ratio for each individual from the mean as measured by each of the two examiners. It is possible to have zero correlations and still have like mean values. These data simply indicate that this group has been consistently described by these two experimenters. In a study conducted by McCurdy and Larson[26] comparing second, third, and fourth readings on each subject for the same and different examiners, they found that the reliability and objectivity coefficients ranged from .70 to .95 for systolic, diastolic, and pulse pressures. They found that the objectivity coefficients for the 4th and 5th phase diastolics are alike. Experiments at Springfield College on reliability of pulse rate normal and after exercise, breath-holding 20 seconds after exercise, and vital capacity, place the reliabilities within the above range. These experiments demonstrate that with very careful measurements the circulatory-respiratory measures are significantly reliable and objective. If, however, higher reliability is desired, as is the case when the test is used for individual diagnosis, two or three repeated measurements under identical conditions, with the average used, will increase the reliability above .90.

Norms.—In the assessment of circulatory-respiratory fitness it is necessary to have norms which describe homogeneous groups in respect to age, sex, and climate. There has been considerable work done in respect to individual circulatory-respiratory items but little in respect to cardiovascular-respiratory test batteries. Ferguson[9] in his study on chronological age, using circulatory-respiratory items and the McCurdy-Larson Organic Efficiency Test on ages 13 to 17 inclusive, found that the changes in the standing pulse rate, sitting and standing systolic pressures, breath-holding after exercise, vital capacity, standing pulse

pressure, and the Organic Efficiency Test were significant enough between the various ages to require single age norms. His study provides age and male norms for ages 13 to 17 inclusive for the items and index score of the McCurdy-Larson Organic Efficiency Test. This study is being continued comparing chronological and physiological age for this test. In a study conducted by McCurdy and Larson,[22] analyzing the ages 18 to 80, they found that by providing for three groups (18–34, 34–49, and 50–80) the correlations were all reduced to zero. Significant physiological differences were found between these groups in sitting systolic pressure (increase with age), sitting diastolic pressure (increase with age between 18–34 and 35–49 periods), decrease in breath-holding after exercise ability (18–34 and 35–49 periods), increase in pulse pressure (in 50–80 group), decrease in vital capacity, and a marked decrease in the Organic Efficiency Index Score. These conditions should be remembered when an assessment of circulatory-respiratory function is to be made. Comparisons made with inadequate norms are worse than nothing as they are misleading.

Cardiovascular-Respiratory Tests.—According to Schneider[39, p. 307] the equipment that enables a man to combat adverse influence is partly inborn and partly acquired. He classifies this equipment into three categories: the morphologic, the physiologic, and the psychologic. The morphologic consists of the physical form and structure determined largely by heredity and also by use. The physiologic are the organs which by graded and frequent use yield capacity for adjustment in activity. The psychologic is the mind, the master of the body machine which acquires greater capacity and adjustment with graded and proper use. The "fitness" of an individual is determined by all three, of which the cardiovascular tests only partially measure one—the physiologic—and reflect the psychologic.[27]

Research workers have used two approaches in the evaluation of circulatory-respiratory fitness: *a*, the evaluation in terms of the oxygen regulating and utilization of mechanisms before and during work as diagnostic and prognostic devices, and *b*, the evaluation in terms of circulatory-respiratory measures such as, blood pressure, pulse rate, minute-volume, etc., also as diagnostic and prognostic devices. As far as can be determined there is no evidence comparing these two approaches, although logically it appears that the two should produce a high correlation.

The purpose of a cardiovascular test is to assess circulatory-respiratory function in terms of single physiologic items and in terms of an "index score" which is the sum of a number of items selected to yield a valid estimate. The scaled and summed items producing an "index score" are supposed to yield more valid physiologic information than a single item. This is partly true and partly false. It is true if the items are selected and weighted on the basis of a physiologic criterion. It may

be false because neutralization may take place between a good item and a poor item to yield a normal physiologic value. One having a very high pulse rate but compensated by a high breath-holding after exercise cannot be considered normal.

There have been a number of constructed tests of cardiovascular function. These tests can be found described in other sources.[23, pp.266-74] There is research evidence for the Tuttle Pulse-Ratio Test [50] as an indicator of non-compensating hearts [4, 18] and running endurance,[10, 13] The McCurdy-Larson Organic Efficiency Test presents experimental evidence showing changes in the index score with (1) age (13 to 80), (2) illness (after fever), and (3) training (cross-country and swimming).

Stine[49] in his review of the literature in connection with heart rate and cardiac output cites three principles and points out the types not responding to these principles. The principles are: (1) Marey's law or the existing inverse relationship between pulse rate and blood pressure; (2) Starling's law or the factor governing the output of the heart is the inflow; and (3) the rate of the heart responds directly to venous return. The three types not responding in accord with above principles are: (1) the individual whose protective tone of the vagus is below par, which causes an increase in the rate (90–110); (2) the individual with a damaged myocardium that will no longer conduct impulses (increase in rate); and (3) the individual with valvular defects which may or may not be compensated. Individuals with compensated valvular defects give normal cardiovascular responses.

NEEDED RESEARCH

Tests of cardiovascular-respiratory function have been constructed (1) empirically using good physiologic judgment (based on experimental evidence) in the selection of the variables and a non-scientific scheme of scaling the results, and (2) employing the experimental-statistical approach evaluating the items in terms of an objective criterion and statistically scaling and weighting the items according to the relative variability of each and the relative significance in describing the criterion measure.

Research needs in terms of "physical fitness" are three: (1) an evaluation of all existing measures of circulatory-respiratory function in terms of a wide variety of criteria objectively representing different degrees of "physical fitness"; (2) a correlation analysis of these measures on different age groups, different sex groups, and under different climatic conditions to determine the "group components" or physiologic mechanisms as a base for experimental work; and (3) a statistical scaling and weighting of significant items in terms of a criterion measure of physical fitness.

The purpose of these researches would be to select measures on the

basis of the physiologic effects of the activity. The assumption used by empirical test constructors that all items are equally important and are affected similarly by activity, is a very questionable one.

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CHAPTER XIII

Mental Hygiene and Physical Fitness

By Harold Seashore

IT IS fortunate that today psychology is oriented to biology rather than to philosophy, thereby removing the "mind-body problem." We now stress the organism-as-a-whole and consider its behavior, some phases of which can best be tagged with the adjective physical and other aspects of which by common consent we label mental. Such terms as mental, physical, conscious, emotional, etc., are now conceived not as names of things or parts, but as *delimiting terms for certain aspects of total behavior of the organism.* This chapter deals with the interrelation of some mental facets of human behavior with the development of bodily integrity and efficiency.

Lewin [5] has proposed a neat formula which gives a working viewpoint for our inquiry: $B = f(OE)$. Behavior is a function of the interplay of the organism with its environment. This formula constitutes a definition of psychology, since psychology is the scientific study of the behavior which results from the interaction of the organism and its environment.

Another fundamental concept is needed before digging into the specific matters of this chapter. Cannon,[1] the physiologist, in his admirable volume *The Wisdom of the Body* has presented clearly the idea that the chief characteristic of living organisms, as contrasted with non-living things, is that they are continually active in the process of maintaining "constant states." Beginning students in physiology are usually thrilled with their progressive learnings about the processes of "homeostasis" or "self-regulation" in the body—the control of temperature, the secretion of appropriate kinds and amounts of digestive fluids, the filtering "wisdom" of the kidney, and the fine control of infinitesimal amounts of minerals, hormones, and vitamins. Physiologically man is a highly homeostatic, self-regulating organism. When he fails to be self-regulatory, he either becomes ill or defective, or he dies.

Other aspects of man's continuous struggle to maintain his constant state or equilibrium are in the province of psychology. Just as on the micro-level of cellular integrity man continuously readjusts himself as a part of the business of being alive, so also on the macro-level—the outwardly observable psychomotor responses and the so-called ideational processes—does man struggle away at the job of keeping his

personality intact and if possible enhanced. This statement does not require the acceptance of any particular theory of motivation, such as Bergson's *élan vital*, or Freud's *Eros*, or Jung's primal urge; it is only an extension of the observed fact that human beings tend to do those things which, as steadily as possible, keep them within a range of behavior that leads to continuance and comfort.

Psychology is concerned with the processes of readjustment. Mental hygienists, psychiatrists, sociologists, and educators are also concerned with discovering the laws of adjustment, proposing practical techniques for preventing and curing maladjustments, and establishing a kind of social order and educational system which will produce maximum personal and social adjustments of each individual.*

The foregoing excursion into some of the theoretical aspects of the modern bio-social sciences suggests that progress cannot be made in our attempts to relate any physical fitness program to the whole field of personal development of people unless we are thoroughly convinced about the unity of the human organism. It is not enough that we assert such a belief and then plan and teach as if the children, adolescents and adults we teach are fractionable into discrete parts. There is no gain in trying to determine what single approach to man and his problems is most important; we reach understanding of man only when we recognize that always the persons with whom we deal are total persons.†

THE PHYSICAL AND EDUCATIONAL IN PHYSICAL EDUCATION

Physical education is today an accepted part of public policy. This was not always so. The validity of this field as a unit in the total scheme of education and social welfare has become established during the past four decades. A profession—with standards, purposes, and controls—has emerged.

Part of the tactics of "selling" physical education to the educators and taxpayers was to identify the aims of *physical* education with

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* For further consideration of psychological adjustment, readers are referred to the following sources, selected for their cogency:

J. F. Dashiell, *Fundamentals of General Psychology*, Houghton Mifflin, 1937.
J. Dollard, and others, *Frustration and Aggression*, Yale University Press, 1939.
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G. Murphy, L. B. Murphy, and T. Newcomb, *Experimental Social Psychology*, Harpers, 1937.
L. F. Shaffer, *The Psychology of Adjustment*, Houghton Mifflin, 1936.

† In the belief that some readers may wish to study aberrant personalities in relation to physcal fitness, we present the following selected bibliography:

J. E. Davis and W. R. Dunton, *Principles and Practice of Recreational Therapy*. Barnes and Noble, 1936.
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those of *all* education. Seven cardinal principles were adopted as goals for education; physical education not only claimed a unique relation to two of these—health and worthy use of leisure—but proved in theory and practice that its program served all the ends of all education. This identification has been quite complete and certainly has enhanced the richness of modern school and extra-school living.

To accomplish these ends, physical education made three important shifts from the program and philosophical emphases of the pre-recognition days. (1) Greater emphasis had to be placed upon activity programs for *all* pupils. Organized interscholastic athletics for the few is still a great American tradition, but physical activities for the many became an educational necessity. (2) Physical education geared into the surging interest in child welfare and public health and in after-school and vacation life, so that today the official professional body is called the American Association for Health, Physical Education, and Recreation. Physical education is part and parcel of a whole-life program. (3) The European tradition of military and formalistic physical activities gave way to the naturalistic games and spontaneous-interest program which quite necessarily followed the influence of Dewey-minded educational philosophers and psychologists.

This identification of the aims of physical education with the aims of all education and consequent emergence of program took place during a period when educational philosophy and practice was in great transition. Schools, generally, were switching from an old-line formalistic program to a newer type of program which agreed more consistently with what emergently has been called the "mental hygiene point of view." Obviously we cannot review these educational gains nor the impact on physical education in particular.

While advances are recognized, it should be noted that the shift from a formalistic, body-building, skill-emphasizing, non-recognized program to an informal, game-stressing, serving-all-objectives, and recognized program, however, has not been all gain.

McCloy[6] has pointed out the importance of the losses and the danger of further losses within the pattern of all-over progress. While he has accepted and promoted the identification of our aims with those of all education, he, and those who follow his thinking, warn the profession not to become so interested in the *general* contribution of physical education to education as to lose sight of the *unique* contribution which only physical education can make.

Many school subjects are socializing, but few are body-building. Many make pupils more book-literate, others stimulate esthetic appreciations. But there is also sincere argument for those who insist on body-literacy and sports-literacy.

Speaking in a mental hygiene framework, we can express the problem thus: in our interest to exploit the physical education program

for other acceptable mental hygienic goals, both loosely and critically defined, we may have missed the point that physical education *practically alone* is responsible for providing certain educational experiences which will develop and sustain sound mental health as well as physical health.

McCloy urges that the biological objectives of physical education stand in danger of being lost. Physical education is a form of applied biology as well as a branch of education. Biological growth, biological integrity, biological efficiency—these are its concerns, first, last, and always.

Physical education has joined the parade, hoisting its banner for the "mental hygiene point of view." All activities must gear in with the mental health view of this age, but again we urge, each department must not become so concerned with its relation to the *generality* of educational aims that it fails to contribute its *unique* competence. Socialization, character, personality, happiness—these and other mental health objectives belong to physical education, but they also belong to Latin and Little Theater. Physical education can legitimately contribute to these long-range objectives only by doing its two unique jobs well.

1. Help each child develop as fine a body as is possible for him, recognizing great individual differences; develop strength, posture, organic vigor, flexibility, and so on, and provide him with the necessary information to plan and control his own living in accord with the best known principles of hygiene.

2. Train each child in the fundamental motor abilities of the human species, such as walking, running, jumping, and so on, and in the combinations of these fundamental activities into sports and vocational patterns.

With McCloy we would not deny the validity of the non-physical goals of physical education, but, rather, would emphasize that, first and foremost, the field is *physical* education. The biological ends must be served first, as the linguistic ends of French and the symbolic ends of mathematics justify those departments in the curriculum.

> It does not seem to me that there is any essential conflict between *education through the physical* and *education of the physical.* Rather the latter seems to be the physiological prerequisite of an adequate education *through* the physical.[6]

Physical education, even from a mental hygienic point of view, must be concerned primarily with all-round physical fitness and ready-functioning skills; any other expectancies from the program must be secondary though not neglected nor denied.

Let us reduce the viewpoint here expressed to specificities. Here again we can but state the point and leave the reader the full responsibility for discovering method and practice. The question is: How can

mental hygiene be served by a physical education program stressing the objectives of physical fitness, per se, and sports-skills?

1. *All-round physical fitness is a desired substrate for all mental health.* We used the word "desired" rather than "necessary" because mental health can be attained by persons with low-rated physical fitness. However, the clinical literature and common observation combine to assert that "a sound mind in a sound body" is more than a philosopher's epigram. It is a first rule in child guidance clinics and other psychological centers to first "repair" a child by medical treatment, nutrition, rest, exercise, and whatever else is needed before hopeful psychotherapy can be planned and in some cases even an adequate psychodiagnosis made. Preventive mental hygienists and curative psychotherapists welcome a program of physical fitness.

2. *All-round physical fitness provides a reserve supply of energy and habits of coordination which are necessary (a) under the day-by-day stresses of modern living, and (b) during emergencies.* Most of us own cars which can run at ninety miles per hour because we believe such a car will wear better at our ordinary speeds of forty to sixty miles per hour. The analogy is plausible. The problems of our modern overstimulating and overdemanding socio-economic community are discussed in another section of this paper. Another analogy. We want a car with quick pick-up, good brakes, and sound steering apparatus, and a carburetor which does not flood when the accelerator demands quick action. There are emergencies in life when sudden output of energy is needed and sometimes the emergencies are sustained for some time. Faith in one's mechanisms during ordinary and extraordinary situations is an important element in mental health.

3. *Every person should be able to defend and protect himself and those for whom he is responsible.* The "peace of mind" which comes from being adequately fit and skilled for ordinary forms of self-defense is not to be overestimated. During war emergencies the need for physical fitness for *personal* self-defense is recognized. The need exists in all life. Every father knows what his child means when he says "my pa can lick anybody." The love of boxing and fighting by children has profound psychological roots for which no mysterious instincts need be postulated. Not that we shall produce a generation of plug-uglies nor create an attitude that anyone whose defense is poor is a legitimate object of scorn or attack. We are essentially civilized, but even today men, and women too, feel better when they are equipped to defend themselves by flight or fight when confronted with socially aberrant antagonists.

There is another aspect to this matter of personal safety. Accidents will occur to anyone, but it is patent that the person who is well-developed in agility, flexibility, and strength, and possesses the general alertness which comes from adequate nutrition and rest, can avoid

more accidents and if an accident does occur can adjust himself better.

4. *A repertoire of well-developed, usable, sports-skills should be a part of the "personality" of every citizen.* It is not necessary here to review the arguments for modern physical recreation nor the reasons why big-muscle, whole-body sports-activities should be given considerable priority during the leisure time of urbanized, sedentary people. The physical and mental implications have been discussed hundreds of times. It is hardly necessary to remind ourselves that many physically complacent people will "get their exercise" in sports recreation when they will resist to the last dumbbell and required formalistic exercises. There is little motive in physical discipline for its own sake.

We wish to stress one point which is a necessary concomitant of the view of this chapter. The character-builders notwithstanding, it is not the "playing of the game" that matters most. It is playing the game *competently* that gives the player those satisfactions which are of such tremendous mental hygienic value. People can get exercise and achieve most of the desired physical goals through formal and informal activities "sloppily done"; at least they can get the proverbial "workout." We doubt, however, if even the strictly physical gains are as great as they can be when persons engage competently in physical activities, be they formal gymnastics or informal games. The physical education department should no more permit incompetent tennis playing than the typing department permits "hunt and peck" methods or the music teacher approves "approximate pitch." Obviously not all persons can acquire equal proficiency and fortunately lower-order performance does yield many satisfactions. Unfortunately, the necessary individualized instruction for skilled performance is often difficult to obtain. However, as mental hygienists, we would state it as a *minimum goal that by the end of secondary school every boy and girl should have attained a working acquaintance with a large variety of sports-skills and competency beyond the novice stage in at least one carry-over sports-skill for each season of the year.* To anyone who has studied thoroughly the psychology of learning, it is apparent that if the program is well-organized and well-taught, this breadth and level of skill can be attained with no loss of character-values or other educational goals.

These four points are the argument which the physical educator can legitimately make for stressing the biological objectives of physical fitness and skilled performance. If he attains these goals in his pupils he will still be within the contemporary flow of educational philosophy and will function effectively as a mental hygienist. This plan will produce direct mental hygienic consequences; there is no need to think of mental hygiene outcomes as being transferred values from the sports-field to "life-in-general." In the process of training boys and girls in the type of program which will lead to these biological ends of fitness and

efficiency, it is apparent that the more generally stated educational functions can also be subserved. There is nothing in the foregoing viewpoint which eliminates stress on sportsmanship, character, socialized living, courtesy, tact, esthetic appreciations, intellectual growth, and certain other more nebulous, yet significant, aspects of total personality.

NEUROLOGICAL HYPERTENSION IN MODERN LIFE

Modern life, in spite of its time-saving, labor-saving devices is hard on man. His living is characterized by an inordinate tempo, of variegated and unintegrated activities, numerous socio-economic conflicts, continuous striving for status and security, and a transition from ruralized, big-muscle living to urbanized, sedentary occupations with their static posturings and highly discriminative, small-muscle vocational activities. There have been numerous statements of this problem before. Questions have been raised as to whether man "can take it." Our answer, since it is not adequately documented, is a matter of faith; it can be expressed thus: "Man can take it; he always has!" The problem of modern social engineers, those who are interested in the rationalizing of man's biology and modern social conditions, is one of learning just what the effects of modern living are and then to promote reorganizations of society which will retain the desired gains of modernity but remove the deleterious factors. In individuals and in society as a whole social catabolism cannot exceed social anabolism for a very long period.

It is the cultural setting described above which has provoked a tremendous literature and research inquiry into problems of fatigue, recreation, neurosis, social conflict, and so on. It is this milieu which instigated Jacobson's famous researches [3] and made his *You Must Relax* [4] a best seller for a season. Among physical educators, Rathbone's research [7] is perhaps the most significant single piece of work. Some of Jacobson's writings and Rathbone's "Residual Neuromuscular Hypertension" are "must" assignments for all physical educators who are working with corrective and physiotherapeutic problems or who more generally feel the need for mental hygienic insight into the problems of unrelaxed people. The earlier literature is listed, and essentially reviewed, in Rathbone's volume; post-1936 literature must be discovered through more recent guides.

What is hypertension? We cannot review all the definitions of the various aspects of fatigue which are necessary to a profound understanding of the problem of hypertension. The essential terms, however, will enable us to point out the significance of the problem and to provoke the reader to be aware of his relation to it.

Hypertension of musculatures always results from activity; it always precedes exhaustion and therefore is an important clinical phenomenon. Hypertension symptoms tell the person to stop using those

musculatures and seek recovery. Extreme hypertension, as the name implies, would be extreme tonic contractions of some muculatures, few or many. Ordinarily, the fatigued condition which has led to the tautness will be relieved by rest. Normal people are often hypertensed from overwork or underrest or some other condition which is reflected in neuromuscular inefficiency. The hypertension can be widespread (all-over tiredness, semi-rigidity) or can be localized ("writer's cramp," the small of the back, a posturing of the neck), but normal rest ends in recuperation.

Residual neuromuscular hypertension refers to the condition when the cycle of tension and release of tension through rest is arrested, when the organism stays at a high degree of tension, when an ordinary life regimen does not relieve or eliminate the tension.*

After reviewing the literature on the possible relation of several medical, social, and psychological factors to tension, Rathbone presents 75 case-studies, with interpretations. The persons were mostly professional people in New York who were clients of her physical education clinic. It is likely that they were not a typical group of people with residual hypertension, but there is no doubt but that they were hypertense and needed special care. To orient our notes on certain mental hygienic aspects of this problem, we shall first present a digest of her "certain general hypotheses" regarding the causation of hypertension in these clients.

1. General appearance may be misleading; tense people may appear to be restless and spastic or calm and poised.
2. Any posturing of a loosely articulated structure like the human body will demand muscular tonus. Persons who must maintain such increased tonicity over sustained periods in static positions will tend to show hypertension.
3. Height and weight seem to bear no relation to tension.
4. Inadequate pulmonary ventilation and consequent inadequate metabolism may be factors.
5. Data on glandular causation are very incomplete and unclear.
6. The locus of the major hypertension may be in the internal smooth muscles or in the skeletal muscles, but tension may be reflected from one kind of musculature to the other. (This may be due to the pain from a localized tension; the pain causes the person to maintain a more or less rigid postural orientation which will minimize the pain experiences.)
7. Data on drugs and infections are inconclusive.
8. Anything which causes extreme residual tension will elicit pain and anything which causes pain will elicit reflex muscular spasms.
9. Emotional strain, a psychological disturbance, will be reflected physiologically in hypertension.
10. Overactivity of any kind is found to be the most common cause of residual neuromuscular hypertension.

* The longer term, residual neuromuscular hypertension, makes reading laborious and since our interest is in clinically serious tensions only, we shall mean this term even when we write tension or hypertension.

One clear notion emerges from a careful study of her data: when we see a hypertense person we cannot designate its cause without careful case study. Further, it is likely that several causes are operating in each case and it is difficult to trace the order of appearance of these causes or their relative importance. What is still more important for us as mental hygienists, an emotional condition (psychic disturbances, the medical fraternity is wont to say) is likely to be present either as a causative variable or as a consequent.

There are persons whose hypertension has begun as a result of an accident during and after which period of injury the person has assumed some static protective posturing of the body. The cause is tissue-injury, the therapy is medical or surgical, but out of the pain and the enforced restriction of normal activities, serious personal dislocations may appear which are as important for the therapist to understand and manage as are the actual injuries.

In other cases, the person has been physically normal but has recently been overworking. It might be an employed woman who besides extra work on the job has had a sick mother at home to complicate her routine. It might be a professional person (Rathbone had several ought-to-know-better physical educators) whose work has become too heavy for him. Under the pressure of work, often in static, non-ambulatory positions, and the consequent loss of rest and dietary disturbances, these persons develop either a localized or widespread residual hypertense condition. Mental variables are functioning both in connection with motivation for the overwork (fear, desire for status, loyalty, ambition, and so on) and on the symptomatological side (pettiness, quarrelsomeness, delusions, neurasthenia, and so on.). The effects of the hypertension from sheer overwork operate as further stimuli to psychological involvement. A vicious circle of physical-psychological causation and resultants is formed. The more the tension increases, the more duties are undone or faultily done; the more one's work becomes neglected the more likely there is to be criticism, feelings of inadequacy, and even loss of employment or status. It is obviously difficult to extricate the physical and mental symptoms and effects from each other and to posit a straight-line order of events or plan of treatment.

These observations carry profound implications for the physical educator. The physical educator, ostensibly responsible for physical rehabilitation, must understand the whole personality, must secure an accurate and reasonably complete social history as well as medical and activity history. Prescriptions are serious things to make in cases like these. Corrective gymnastics, per se, may or may not be needed and even when gymnastic activities seem physically indicated, they may be ineffective or positively dangerous until a suitable frame of mind, some emotional reorientation, is attained. Further, the physical director, either himself or by delegation, may need to see what can be done

about the social-economic situation out of which these problems emerged; it may mean vocational guidance, it may mean consulting with employers, colleagues, and social agencies.

In other cases the hypertension is frankly neurotic. Rathbone tends to avoid classifying any cases in this way. In some of her cases the physical symptoms which brought the cases to the clinic, usually after many medical wanderings, indicate neurasthenia or hysteria. The person is manifesting physical disorders because of anxiety, fear, feelings of guilt, inferiority feelings, and other "standard" reasons with which psychiatrists are familiar. Mental conflict, and the consequent repression, has led to a general and persisting "tightening" of the person. All of us occasionally tighten up during fright, grief, and temporary anxiety; the feature of our client's difficulty is the persistence of these symptoms which all of us show in transitory forms. No one is properly equipped to diagnose and handle such cases until he is adequately versed in the etiology, symptomatology, diagnosis, and therapy of neurotics. This does not mean that physical directors must be psychiatrists; it does mean that they must be able to understand the interplay of mental and physical variables, to know when psychiatric counsel is needed, and to cooperate in a therapeutic program which subserves the psychiatric and physical needs of the person. Fundamentally, the real cause of the "psychic disturbance" must be located before permanent relief can be expected.

We agree with Rathbone in her emphasis on overactivity, whether in the form of "necessary" activity of well-balanced people or the manic hyperactivity of certain types of people. Sometimes rest is more important than exercise. Physical educators must beware adding to the already overstimulated daily routine of school children. Fundamental solutions may involve changes in style of living and of working conditions. The physical educator is responsible for observing the motor signs of tension in the behavior of persons under his care. Not only during official examination, but in physical activities, he should be aware of tell-tale signs. Rigid posturings, restless "jittery" movements, and excessive tempo of activity are signals. In addition to noting these overt motor signs of tension, he should be able to make tentative inferences concerning actual or potential hypertension from the conversational content and attitude of the person.

Needless to say, our alertness to actual or budding hypertension should not make us over-suspicious of all deviations which occur. The signs should stimulate further inquiry, not snap judgments.

Many other significant recommendations of immediate practicability could be presented from the writings of Rathbone, Jacobson, and other experts in this field. Since perspective rather than prescription is most vital just now, our interest turns to the relation of the mental hygienic problems of residual neuromuscular hypertension to problems of na-

tional physical fitness. Whether the cause is in mental disturbance or in physical injury or overwork, a major portion of the prevention and cure of this condition lies in teaching people how to stand, to walk, to lift things, to eat, to sleep, to relax, to play with big muscles, to be concerned about physical disability without developing hypochrondriasis, to regiment themselves twenty-four hours a day for total living. Further, physical educators share the responsibility for promoting public and school health programs which will improve working and living conditions in industry, school, and home. Persistent static posturings without relief can be eliminated. Emotional tensions, though hard to detect and manage, can be alleviated. "Job pressure" and social demands can be adjusted to the abilities of people to cope with them. Overall improvement in organic health and development of physical vigor and skills will stand a nation in good stead should it be called upon to go "all out" in an emergency period during which partial moratorium on ideal living conditions is necessary.

In conclusion, the intimate relation of psychological and physiological variables in residual neuromuscular hypertension, both as to causes and effects, implies that there must be a mutual liaison between the physical educator and the other specialists whose sciences and applicational techniques bear upon the problem. Fractionated programs are a thing of the past. Medical directors, school and public nurses, social workers, personnel men in industry and business, school administrators, and clinical psychologists must share in the opportunity for helping modern man to "take it" in a culture which he himself has created with such complications that it threatens to destroy him.

PHYSICAL FITNESS IN CIVILIAN AND MILITARY MORALE

"Everybody" knows what morale is! Few can define it formally and many find it difficult to describe how it arises and what its effects are. However, the athletic coach, the industrial personnel manager, the military commander, and the parent know when morale is high and when things seem not to hang together well in the group with which they are concerned. Napoleon said, "In war, the morale is to the physical as three to one." The current term, "war of nerves," implies that the victory will be determined by morale of the people from top ruler to infant bomb-recipient. "We're sailing against England" and "There'll always be an England" are morale techniques on the present scene; among the fighters and civilians, alike, they have military value equivalent to tanks and headlines reporting success.

Because many people use the term morale as a label to "explain" the phenomenon under observation, it is necessary to formalize a definition and give an exposition of its major variables. Dashiell says that the person with high morale: ". . . shows a *greater amount* of energy expenditure in more *tenacious* ways, that are constructive and concerted.

And the activity is supported by an *emotional* condition of sthenic, or *reenforcing* type (variously named 'zest,' 'élan,' 'hope,' 'confidence')."[2]

Certain terms in this definition—energy expenditure, sthenic, tenacious—are significant for experts in physical education who are seeking their role in national morale.

Psychologists list four main variables in morale-building, which factors, one can readily see, operate in all situations whether they be in the army, the factory, the school and the family, or are more strictly personal.

1. *Physical Fitness.*—Morale is more attainable and enduring if men are well-conditioned, free from disease and correctable defects, well-nourished, trained in hygienic habits, and skilled in necessary personal and vocational activities. Such men will be more trainable in activities demanding physical force and endurance. They will be in condition to show tenacity. They will be more disease resistant and show greater recuperating power. They will be able to function better at high speed and under great strain during emergencies. The physical fitness factor operates as a substrate for the more strictly mental and emotional aspects of morale.

Physical fitness also depends considerably upon the adequacy of the physical environment—food supply, housing, sanitation, control of disease, hospital facilities, etc.

While we are necessarily concerned at present with the administration of the military program so that the morale arising out of physical fitness will be attained, we need also to point out that the civilian population, now as well as in more normal times, maintains its morale upon the same bases. It is unfortunate that too many persons and communities get excited about total physical fitness of their late adolescents only during emergencies. Physical educators must join the crusade for permanent interest in programs for all-round, all-age, everyday physical fitness.

2. *Idealized Goals.*—Persons with high morale—in the military or otherwise—must be convinced that their specific program of action and general attitude toward life is just, necessary, and personally more important than some other course of action or viewpoint. "Thrice-armed is he who has his quarrel just." The idealized goal need not be a factually true goal nor need it be based upon integrity of logic or fact. The techniques of building idealized goals can be used with facts or with rumor or with outright perversions. It is only necessary, at least for building temporary morale, that the persons involved believe the goal must be attained. It is our belief, as persons educated in a world-view and in science, that truth ultimately will win. One of our major problems is to show ourselves how details of action today and tomorrow have a bearing on our faith in the goodness of man and the irrepressi-

bility of truth. This is not the place to discuss the techniques of education (and its special techniques which are subsumed under the heading propaganda); we need only assert to ourselves that as physical educators we must know where we personally stand on issues outside of our field and what we propose to do about them.

3. *Confidence.*—Morale depends upon faith in ultimate success. Often immediate sub-successes are vital to morale. "Nothing succeeds like success." This epigram has important exceptions, but is generally valid. When setbacks in one phase of activity occur, compensatory successes are necessary. Every student of mental hygiene knows about the role of compensations in personal morale; national or military morale functions in a similar way. The army either succeeds or believes it is about to succeed, or else it breaks. The athletic team succeeds, believes it can succeed, or it breaks up in ignominious rout. Small battles won, belief that a new job is around the corner, that one can learn a vocation or profession in four years of high school or college, belief that one's parents will not let one down—these, based upon observed facts and expressions of security, are the stuff of morale.

Public morale is related to confidence in economic values, in old-age planning, in job security, in governmental integrity, in military efficiency, in personal morality of citizens, in accuracy of newspapers, and in a host of other ways.

Physical educators will observe that confidence, as a separate variable in morale, is in turn partly dependent in faith in one's own physical prowess. Confidence that one can "take it" is a vital factor. It is here that the plan of pre-war military training has partial justification; men who are trained in military activities, are physically conditioned, and have learned the essential skills are more likely to be confident than those who question their endurance and strength, their ability with arms, and their plan of action. We have been told that many casualties of the last war must be chalked up against physical unfitness, against too little conditioning before engagement in front-line activities. Now we believe that faith in oneself based upon preparation is essential to morale.

4. *Recreation.*—All forms of social and physical recreation, particularly those which unite the whole group into informal non-required activities, are necessary for morale. Some people wonder why the army camps need boxing arenas and baseball diamonds and why London during months of bombing has kept open its centers of entertainment. Even humor rises during distress. The lightheartedness of the soldier riding to the front line is vital. If people cannot play they will break. Families know this; when parents and children can play together, even after a bitter struggle with the budget, there is family solidarity. When workers who turn nuts and press levers can holler "play ball"

on the neighborhood diamond, winning for dear old Phoenix Salt Fish Company, there are after-effects in the packing house. When teachers can play as well as tutor, learning is facilitated.

The physical educator joins with other recreationalists in providing programs for civilian and military communities. It is hard to estimate what the WPA and other recreation programs did for the American people during the past financial depression. In any crisis, play is vital. Ours is the job to provide an organized program which will "take people out of their concerns," for re-creating their personalities and bodies.

Recreational centers should be organized so that persons with well-established recreational patterns can execute them. Not all need to play ball; some need to sit down and talk with fellow-hobbyists. Certainly athletic programs in the army camps are not necessary to give the men physical workouts; their object is entirely emotional recreation. For some this emotional recreation might come from observation, for some from participation, for most it will involve a variety of activities. It is not necessary here to discuss any further the methods and scope of programs or their administration. We need mainly to understand the function of recreation in morale.

Morale, then, is a concern of the physical educator. He is uniquely responsible for the first variable and considerably for the fourth. The idealization of goals and the growth of confidence, while not particularly his field, are adjunct to it and thus become his concern. And, finally, in a time of military emergency, it behooves the physical education profession to keep itself alert to the morale needs of the total population and to plan for a transition period following the emergency.

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CHAPTER XIV

Tests and Measurements in Health and Physical Education

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NATURE AND SCOPE OF MEASUREMENT IN HEALTH AND PHYSICAL EDUCATION

RECENT research in the fields of health and physical education measurement has resulted in a new philosophy. During the period preceding approximately 1925, tests were constructed empirically. The criterion was usually the investigator's judgment and the objective to select items which would yield rather complete health and physical diagnostic and prognostic data. This early procedure was to construct the test, then determine the relative merits of it through application. This procedure resulted in many disappointments. These disappointments have two sources: first, the construction of the tests failed because the items were not selected from all phases of human ability and capacity, and second, the tests failed because it is necessary to know what application is to be made of a test *before* test construction. The application serves as a base for research.

The modern philosophy underlying research in these fields takes cognizances of these weaknesses. Research workers are working vertically within *one* phase of ability or capacity to determine the relative significance of the various measurable functions and traits within that phase. The items and tests are evaluated in respect to a specific ability, trait, or capacity criterion. This philosophy recognizes the point that the phase may be valuable diagnostically and prognostically in one situation and not in another, also that the various functions of the phase have relative degrees of validity in application. The introduction of statistics as a tool in research has given impetus to this philosophy. The relative values of test items can be determined only through the use of statistical methods. In summary, the modern objective is better tests of strength, nutrition, cardiovascular-respiratory function, etc., and evidence of validity as a step in the process of test construction.

Measurements in health and physical education in terms of the individual can be classified into two groups: those of performance and those of non-performance measurements. In the performance classification the tools for recording are instruments in the form of tests, instruments in the form of apparatus, and instruments in the form of

rating scales. In the non-performance classification the tools for recording are instruments in the form of apparatus, such as, the tape, the caliper, etc. The performance tests can take the form of the criteria of ability or capacity, or they can take the form of the recording of the various functions of the body so as to better understand the ability or capacity for diagnostic and prognostic purposes.

Many people use tests but a high percentage are in the form of the final performance. In industry, for example, if information is desired as to whether one has a sufficient degree of physical fitness to master a job, the test frequently is the job. Such procedure does not make any diagnostic or prognostic contribution to the individual; it has practical but very little educational value.

BASES FOR A FUNCTIONAL PROGRAM OF TESTS AND MEASUREMENTS

In preparing a program of tests and measurements in any field one is confronted with three problems: first, the problem of the *scope* and *limitations* of measurements. According to McCall [15] things that exist, exist in amount and can be measured. The problem, however, is the selection or invention of reliable and accurate measurement devices for the measurement of the various physical and mental traits, abilities, or capacities. All have not as yet been discovered and those that are known are not infallible. One must therefore deal with some inaccuracies. The second problem is that of the selection of tests and measurements according to some standard of significance. These standards of significance are in the form of test criteria: validity, reliability, objectivity, norms, and administration. A selected test must meet the levels of significance in each of these criteria. Third is the problem of the selection of significant tests to serve the objectives desired, either or both, program objectives and individual objectives. In an educational program these two go together.

There are tests and measurements now available that measure significantly the various physical and mental objectives as they pertain to health, physical education, and recreation. These are, omitting the medical examination: muscular strength, muscular development in relation to age and weight, posture, cardiovascular-respiratory function, nutrition, metabolism, motor ability, motor capacity, motor educability, character in physical education situations, knowledge of health, knowledge of safety, knowledge of rules and regulations of physical education activities, and leadership. Tests and measurements selected from the above groupings should be considered *specific* in their relationship to each other. This does not mean that they are unrelated, but the relationship is not high enough for prediction of one phase, given several others.

Tests to be used in a program should be selected with the utmost care. There are many tests available, some of which cannot successfully meet the test of significance. Before the tests are selected, according to test criteria, it is necessary to define the administrative possibilities in terms of time, equipment, and examiners available. Under these defined conditions tests should be selected on the basis of the following criteria: first, *validity*. The test must have statistical evidence, utilizing sound data, that it significantly measures what the author claims it measures. It is also good procedure to critically analyze the criterion used so that the statistical value will be meaningful. Second, *reliability*. The test must have statistical evidence showing that it measures consistently the same function. It should be kept in mind also that errors are of two kinds: constant errors and variable errors. Constant errors are not reflected in test reliability because they are of the same magnitude and in the same direction. For example, a tape one inch in error will reflect *at least* one inch error in objects measured. Variable errors vary in both directions, therefore can be neutralized by the averaging process. For example, in throwing for accuracy, one may be so fortunate as to hit the "bulls-eye" with the first throw, but this does not establish throwing accuracy on the part of the subject. Putting in golf is another example. In order to establish individual accuracy a number of trials must be allowed to establish individual variance. In order to compare individual accuracies the mean is used after the curve of variance has become stable. The reliability of a test can be increased to any desired amount by repeating the test and then using the average score. If learning occurs in the repeating of the tests, it is necessary to prepare a parallel form test. The process of averaging is not applicable to *capacity* tests. These tests should be repeated until the high score is consistently secured. Third, *objectivity*. The considerations are the same as in reliability; the difference lies in a comparison of the results when different examiners apply the tests. Fourth, *norms*. A test can be used without norms, but its diagnostic value is then limited. Proper norms represent a real need in the fields of health and physical education. A norm or "what should be" an individual's achievement can be available only when the function has been evaluated statistically in respect to all factors causing variations in that function other than the function itself. For example, during the adolescent period particularly, muscular strength varies with age. When preparing strength norms, therefore, strength must be divided into homogeneous enough age groupings to eliminate the age difference. The real problem in health and physical education tests and measurements is the location of the *causal* factors.

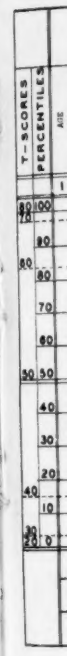
Tests and measurements in a program of health and physical education are valuable only if they help serve the individual more effectively. The selection should be made on the basis of the phases of health

and physical "make-up" in which one wishes to show individual status or individual improvement. The application may be in the form of individual participation in a given program, or influence of various types of programs on the individual. The selection of tests can be as wide as the measurement of the objectives of health, physical education, and recreation. If one is interested in showing how the program meets the physical fitness objectives, tests of physical fitness are selected. The problems are the selection of tests, that satisfactorily meet the test of significance, from the various constituent phases of physical fitness, and the proper interpretation of the results. Physical fitness interpretation resulting from the measurement of its various constituents may take the form of a minimum fitness necessary for good functioning of the body organs necessary for good health and the fulfillment of the daily tasks, or it may take the form of a maximum fitness necessary to master tasks of endurance. The need in the field of tests and measurements is the simplification of tests so that the selection and application includes all the objectives.

THE ADMINISTRATION OF A PROGRAM OF TESTS AND MEASUREMENTS *

In the preparation of a program of tests and measurements one must give consideration to tests of "present status" and also to tests of "innate capacity." Present status tests will indicate the characteristics of the individual; these characteristics determine what the individual is capable of doing *now*. Tests of innate capacity will indicate the limit of development. Both types of knowledge are valuable for the preparation of a scientific program of health and physical education. Tests and measurements of the first type which are available are: medical examination (including the examination of the teeth, nose, tonsils, lungs, heart, abdomen, glands, urine, ears, medical record, activity history, eyes, and weight); tests of muscular strength; tests of strength development in relationship to age and weight; tests and measurements of posture; tests of cardiovascular-respiratory function; tests of nutrition in the form of bone, muscle, and fat proportions; tests of flexibility; tests of metabolism; tests of the composition of the blood; tests of motor ability; tests of motor educability; tests of character in the form of rating scales utilizing the components of character of decisiveness, dependability, self-confidence, etc.; tests of knowledge: health, safety, and rules and regulations governing physical and health education activities; and tests of leadership in the form of rating the components of that quality. Proper scaling of leadership components represents a need. Tests and measurements of the second type (innate capacity) are rare. What the limits of motor development, cardiovascular-respiratory development, strength development, etc., are for each

* Appended profile prepared by Dr. T. K. Cureton.



PROFILE OF HEALTH, ATHLETIC CONDITION, AND PHYSICAL ABILITY INDICES

| T-SCORES / PERCENTILES | | NUTRITION AND PHYSICAL DEVELOPMENT | | | | | | | | | | | | | | | STRENGTH ANALYSIS | | | | | | | | | | | | | | |

N, AND PHYSICAL ABILITY INDICES

| GENERAL HEALTH AND CONDITION INDICES | | | | | | | | | | | | | | MOTOR ABILITY AND ATHLETIC APTITUDE | | | | | | | | | | | | | |

individual is yet to be determined. At the present time, therefore, test users must be contented to work from "present ability" assuming that the program will contribute to the development of all individuals.

Assuming that a program of tests and measurements in health and physical education should include tests yielding information in respect to all measurable objectives, the following may serve as a program.*

I. Tests and Measurements Administered *before* the Teaching Program.

A. Medical Examination:[7] medical history, body types, musculature, posture, spine, abdomen, arms and hands, thighs and legs, feet and toes, skin, height and weight, head and neck, eyes, ears, nose, mouth and throat, respiratory system, circulatory system, digestive system, genito-urinary system, and nervous system.

B. Cardiovascular-Respiratory Tests:

1. Tuttle's Pulse-Rate Test.[24]
2. McCurdy-Larson Organic Efficiency Test.[18]

C. Strength or Motor Ability Tests for Classification.

1. Rogers' Strength Test.[22]
2. MacCurdy's Physical Capacity Test.[17]
3. Springfield Strength Test.[14]
4. Achievement Scales of "General" Motor Ability.[20, 5, 3, 4]
5. Sports Tests.[12]

II. Tests and Measurements Administered *in conjunction with* the Teaching Program.

A. Posture.

1. MacEwan-Howe Posture Measurement.[19]
2. Brownell Scale for Measuring Anteroposterior Posture.[2]
3. Iowa Posture Test.[16]

B. Nutrition.

1. Franzen Index of Nutritional Status.[8]
2. ACH Index of Nutritional Status.[10]
3. Springfield Index of Nutritional Status.[6]

C. Muscular Strength in Relation to a Norm.

1. Rogers' P. F. I.[21]†
2. Springfield Muscular Efficiency Index.‡

D. Character.

1. McCloy Character Rating Scale.[16, pp. 277–92]
2. Blanchard Character and Personality Rating Scale.[1]

E. Health Knowledge Tests.

1. Gates-Strang Health Knowledge Tests.[11]
2. Franzen Health Education Tests.[9]
3. Kilander Health Knowledge Tests.[13]

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* One test may be selected from each grouping. The test selected is determined by the time and equipment available, and whether information is desired in that particular phase.

† For recent norms, write: Boston University Book Store, Boston University, Boston, Massachusetts.

‡ Norms are now in process of development. L. A. Larson, Springfield College.

F. Safety Knowledge Tests.[23]
G. Physical Education Knowledge Tests.*
H. Leadership.†

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